MEMOIRS

OF

THE LIFE

OF

SIR HUMPHRY DAVY, BART.

LL.D. F.R.S.

FOREIGN ASSOCIATE OF THE INSTITUTE OF FRANCE, &c.

BY

[illegible]

[illegible]

IN TWO VOLUMES.

VOL. I.

LONDON:

PRINTED FOR

LONGMAN, REES, ORME, BROWN, GREEN, & LONGMAN,

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PATERNOSTER-ROW.

1836.

BZP (Davy)

" Vita enim mortuorum in memoria vivorum est posita." — Cic. *Philip.* ix.

" The affections are their own justification. The Light of Love in our Hearts is a satisfactory evidence that there is a body of worth in the minds of our friends or kindred, whence that Light has proceeded."

Wordsworth, *Essay upon Epitaphs.*

London:
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ADVERTISEMENT.

This work was written in Malta, and was completed in the summer of 1832. The delay that has taken place in its publication, owing to my protracted "foreign service" on the Medical Staff of the Army, though much against my wishes, has not been without some advantage, as it has enabled me to reply to certain observations which I never could have anticipated, and to give some additional information.

Fort Pitt, Chatham,
Dec. 24. 1835.

PREFACE.

The Life of Sir Humphry Davy, by Dr. Paris, has been before the public a considerable time. In the preface, Dr. Paris expresses much delicacy of feeling about undertaking it, which I am very much at a loss to reconcile with his conduct. That I may not appear unjust to him, it is necessary to quote the passage. After noticing some biographical sketches, which he contributed to the "Spectator," soon after my brother's death, he proceeds to remark, — "I was soon recognised as the writer of these sketches; and the leading publishers of the day urged me to undertake a more extended work. To these solicitations I returned a direct refusal; I even declined entering upon any conversation on the subject, feeling that the wishes of Lady Davy, at that time on the Continent, ought, in the very first instance, to be consulted on the subject. Had not the common courtesy of society required such a mark of attention, the wish expressed by Sir Humphry in his will would have rendered it an imperative duty. On her arrival in London, in consequence of a letter she addressed to Mr. Murray, I requested an interview with her Ladyship, from whom I received not only an unqualified

permission to become the biographer of her illustrious husband, but also the several documents which are published with acknowledgments in these memoirs. I still felt that Dr. Davy might desire to accomplish the task of recording the scientific services of his distinguished brother; and had that been the case, I should, most undoubtedly, have retired without the least hesitation or reluctance,— but I was assured by those who were best calculated to form an opinion upon this point, *for he was himself absent from England,* that motives of delicacy, which it was easy to appreciate, would at once lead him to decline an undertaking embarrassed with so many personal considerations."

Now, to justify what I have said above respecting Dr. Paris's expressions not according with his conduct, it is necessary for me to state,—first, *that I was in England a fortnight after Lady Davy;* that I remained in England from November, 1829, till the end of March; that I was a great part of that time in London, engaged in editing my brother's last work, which, with all his other MSS., he had bequeathed to me; that Dr. Paris knew I was in England, and met me in society, and yet never made any communication to me relative to the work which he was then contemplating. Secondly, I consider it necessary to state that before I came to England no friends of mine had written to me, or had heard from me respecting my intentions; and that no one at that time could with any propriety have formed an idea whether I

should consider it advisable or not to undertake myself the biography of my brother. Indeed, for a considerable time, I was undecided in regard to it. My determination was not formed till after I had examined the documents in my possession, — the various MS. note-books and journals which my brother had left me. As soon as I had made this examination, and perceived the value of these papers, I no longer hesitated, — I felt it an imperative duty to undertake the task; and I accordingly announced this my intention to many of my friends, long before the publication of Dr. Paris's work.

The nature of Dr. Paris's work confirmed me in my design. There appeared to be much in it that was objectionable, many things which were incorrect, and that the general tone and tendency of it were to lower the character of my brother in public estimation; not, indeed, as a man of science, and an original inquirer, but as a man and a philosopher; and to deliver his name to posterity with a sullied reputation, charged with faults which he would have indignantly repelled if living, and which it has become my duty, believing the charges to be unfounded, not to allow to pass unrefuted, now he is no more.

In writing the Life of my brother, which I now offer to the public, from the commencement to the termination of my labour I have kept in view one great object,—the developement of his character as fully as possible, trusting that his best vindication from calumny will thus be ensured; and believing,

with his excellent and attached friend Mr. Poole, that "the more his *whole being* is known, the more the *man* will be esteemed and loved, the more the philosopher thanked and venerated."*

Malta, August 14. 1832.

* From a letter to the author.

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OF

THE LIFE

OF

SIR HUMPHRY DAVY.

CHAPTER I.

SIR HUMPHRY DAVY'S PARENTAGE.—STATE OF PENZANCE, HIS NATIVE TOWN, IN THE MIDDLE OF THE LAST CENTURY.—PARTICULARS OF HIS INFANCY AND EARLY YOUTH, AND OF HIS SCHOOL EDUCATION.—STUDIES AFTER LEAVING SCHOOL.—EXTRACTS FROM HIS EARLIEST NOTE-BOOKS.—PORTIONS OF HIS EARLY POETRY.—THE COURSE OF HIS STUDIES FURTHER ILLUSTRATED BY EXTRACTS.—ANECDOTES OF THIS PERIOD OF HIS LIFE, RELATING TO HIS HABITS, FEELINGS, AND PURSUITS.—HIS APPLICATION TO CHEMISTRY, FIRST ENTERED ON, AS A BRANCH OF MEDICAL STUDIES.—RAPID ADVANCE.—CORRESPONDENCE WITH DR. BEDDOES ON THE THEORY OF HEAT AND LIGHT.—QUITS PENZANCE FOR CLIFTON, TO BECOME SUPERINTENDENT OF THE PNEUMATIC INSTITUTION.

It is with no ordinary feeling of pleasure, no less than from a strong sense of duty, that I engage in this work of a brother's biography:—Of pleasure, considering the circumstances of his life; how, from a comparatively humble origin, solely by his own exertions and abilities, he raised himself to distinction, and acquired a name and reputation which, from its connection with science, can hardly be less permanent than science itself:—Of duty, from

reflecting on the misrepresentations to which his fair fame has been exposed since his death, and which, if not corrected, must necessarily be permanently injurious to his character; — to the "good name" which is "the proper inheritance of the deceased *;" tending to hand him down to posterity not as he was, but as he was imagined to be by the envious and malevolent.

Before I enter on his early life, it is necessary to give some account of his parentage. His father's family, for more than 200 years, had resided, and had possessions, in the parish of Ludgvan, in the Mount's Bay, in Cornwall †; how much longer is not known. In the parish register their births and deaths are entered as far back as 1588, and the register itself does not extend beyond 1566. During the whole of this period the family belonged to the middle class; and on their tombstones in the parish churchyard, the term yeoman is used occasionally to designate them, ocasionally that of gentleman.‡

* Bacon.

† There is amongst some family papers a letter from my father's grandfather, Mr. Robert Davy, to the Duke of Bolton's steward, dated 14th July, 1737, respecting a leasehold property which he says "had been held some hundreds of years by the family, who were some of the oldest and largest tenants in the manor of Ludgvan Lease."

‡ The two following inscriptions, which may be interesting to some readers, as specimens of the old tombstone style of writing, are on tablets in the church of Ludgvan, over the pew which belonged to the family: —

"Catherine, the wife of Nicholas Davy, yeoman, was buried the 18th day of July, 1635.

Death shall not make her memory to rot,
Her virtues were too great to be forgott.
Earth hath her earth, which must yeild it againe;
Heaven hath her soul, where it must there remaine;
The world her worth, to blazon forth her fame;
The poor relieved do honor still her name.
Earth, heaven, world, poor, do her immortalize,
Who dying lives, and living never dies."

The origin of the family is far from certain. My brother, who at one time made some inquiries respecting it, was of opinion that it came from Norfolk, and he thought it probable that the first member of the family had settled in Cornwall as steward to the Duke of Bolton, who had large possessions in the Mount's Bay. This belief was founded in part on what he had learned when a boy; that a remote ancestor, in affluent circumstances, a steward of the duke, had once entertained him on a visit which he had made to his Cornish estates; and partly on the circumstance of an old family seal bearing the arms which belong to the Davys of Norfolk. Be this as it may, there was in the family a tradition, that they were originally of Norman extraction, and had come over with William. This is alluded to by my brother, in the "Consolations in Travel." In the 5th dialogue, evidently speaking of himself, he says, "My parentage was humble, yet I can believe in a traditional history of my paternal grandmother, that the origin of our family

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"In memory of A. D., wife of R. D., of this parish, gent., who departed this life the 2d day of December, in the 45th year of her age. Anno Domini 1706.

Inhumed in the obscure grave doth lie
A just idea of true piety:
In words discreet, sweet was her conversation;
A loyall wife, divine in contemplation;
Unto her friends, her neighbours always kind,
The poor, alas! her equal cannot find.
Opprest with grief, fountaynes of tears they shed,
And dayly cry, our liberal friend is dead.
Desist your mourning, — tho' from hence she's gone,
A glorious crowne by dying she hath wonne.
Let virtue be your guide that her survive,
And to surmount her heavenly actions strive,
Whose constant actions, sole delight and care,
Pious discourse, ejaculations rare."

was from an old Norman stock." His mother's family was that of the Milletts. According to tradition it too was of Norman extraction, and came over with the Conqueror; and according to another tradition, at a much later period there were three brothers, one of whom settled in Buckinghamshire, one in Middlesex, and the other in Cornwall. The records or written notices of this Cornish branch, to which my mother belonged, do not extend back further than the time of Elizabeth. It is stated by Gilbert, in his historical survey of Cornwall, that William Millett, of Marazion, was sheriff of the county in the reign of the queen just mentioned, namely, in 1556; and that Robert Millett, a naval officer, perished with Sir Cloudesley Shovel, on the 22d October 1707, when shipwrecked on the rocks of Scilly; and the belief of the family is, that he was the admiral's secretary. In regard to rank, this family may be considered as pretty much on a par with the preceding. It multiplied more, and was more divided. There are now in the west of Cornwall three or four different branches, who have nearly forgotten their common origin.

This general account may suffice for the paternal and maternal families of my brother. As to his parents, it may be necessary to enter into some details more minute, both as relating to the circumstances which might have had an influence on the formation of his character in early life, and also because Dr. Paris has fallen into mistakes respecting them.

The father of my brother was Robert Davy, the eldest son of Edmund and Grace Davy. The former was a respectable builder. The maiden name of our

grandmother was Adams, and her mother was a Eustick, one of the oldest families in Cornwall. She had, on her marriage, a dowry of 1500*l.*, which, a century ago, in that remote part of England, was considered a handsome fortune. I shall have occasion to revert to her again in relating the circumstances of my brother's infancy and boyish days, as the peculiarities of her mind could not fail to have influenced his.

Our father was brought up in the house of Mr. Robert Davy, the contemporary, neighbour and intimate friend of the able historian of Cornwall, the Rev. Dr. Borlase, the Vicar of Ludgvan. This our great uncle had a landed property, which then yielded an income of six or seven hundred pounds a year. He had no children, and as it was his intention to have made his favourite nephew his heir, he was averse from his following any business. But having a great fondness for carving in wood, he prevailed against his uncle's wishes, and was sent to London to be taught this ornamental art; and it is said that he acquired such proficiency in it, had such dexterity in all its manipulations, and such good taste, that had this art, then expiring, received the encouragement of some other of the fine arts, he would have risen to eminence in it, and have enriched his family. In regard to expectations of wealth from his uncle, he was also doomed to disappointment. Mr. Robert Davy died suddenly in 1774. A rough draught of a will was found in favour of my father, but no attested one could be discovered. In consequence, the principal part of the property, which was freehold, came into the possession of a niece next in succession in the direct

line of descent. The death of his uncle happened about two years before my father's marriage. This took place in 1776. For some years after his marriage he resided at Penzance, and though he did not give up entirely the business to which he was bred, he was more occupied in farming a small copyhold property called Varfell, which belonged to him, in the parish of Ludgvan, where he built a house, and ultimately lived entirely. He died in 1794, after a tedious illness, of a complaint of the trachea, in the forty-eighth year of his age. From the best information I have been able to obtain respecting him, he was a person of some capacity and ingenuity. He was of a studious turn, and fond of reading; and for the welfare of his family, too fond of making experiments in farming, and of engaging in the hazardous and too generally losing concern of mining. He was a man of small stature, even less than either of his sons, but well and actively made; and he delighted in shooting and fishing. Our mother's maiden name was Grace. She was the third and youngest daughter of Humphry and Elizabeth Millett, both of St. Just, the most western parish in Cornwall, and which is distinguished for the purity and wholesomeness of its climate, and for the shrewdness and acuteness of mind of its inhabitants. Both our grandmothers belonged to this elevated district; both were Adamses, though of different families, and were considered in that poor country as heiresses. Mr. Millett was engaged in business in the adjoining town of Penzance as a mercer. He and his wife died young, and in the same week; he on the 3d of June, 1757, and she on the 9th. But she was not aware of his death, as stated by Dr. Paris; she was

only informed that he was too ill to be with her. Nor is it a fact, that in dying she entreated her friend and medical attendant, Mr. John Tonkin, to have compassion on her children (as is also stated by Dr. Paris), and befriend them in their destitute condition, or that he took them to his house and maintained them. He indeed was their friend, and supplied the place of a father to them, and they retained through life a most grateful sense of his kindness, and of the great obligations they owed to it. The truth is, that at the time of the death of Mr. and Mrs. Millett, he was residing in their house, (I suppose in lodgings,) and there he continued to reside for some years, the children being under the care of a Miss Peggy Adams, their cousin, in whose name the mercer's business was continued, by the profits of which the family was chiefly supported.

My mother lived to the advanced age of seventy-six; and, in all the various situations of life in which she was placed, she so conducted herself as to gain the regard and good-will of every one. She possessed a most kind and affectionate heart, a pious mind, sound understanding, and perfect integrity. She was devoted to the performance of all her duties, and was remarkably free from all guile and foolish pride. When she became a widow, she was in her thirty-fourth year, with five children, all of whom were still to be educated, excepting Humphry her eldest son. Her income at this time was about 150*l.* a year, and it was encumbered with a debt of about 1300*l.*, contracted by my father, chiefly in consequence of losing speculations in mining. Her good resolutions did not fail her on this trying occasion. She met all her difficulties with courage

and prudence, and by economy and exertion, aided by the kind indulgence of creditors, and some property falling in hand, even when least expected, she was able to bring up her family in the manner she could wish, and gradually to liquidate the whole of the debt. My brother, at the time of my father's death, was sixteen years old. Seeing her in great affliction, he in a very affectionate manner begged her "not to grieve," saying, "that he would do all in his power for his brother and sisters." She soon after removed from Varfell to Penzance, and, to aid in extricating herself from her pecuniary difficulties, she engaged in partnership with a young French lady, who, with her sister, had fled to England at this period of the French Revolution. She had some knowledge of millinery, and she had principal charge of a shop which was opened in their joint names. This partnership was continued three or four years; it was dissolved in 1799, when my mother entirely relinquished the business, on a small estate, which increased her income to about 300*l.* a year, unexpectedly coming into her possession.

The state of society in the Mount's Bay only half a century ago was so peculiar, and different from what it is at present, that it requires to be noticed, not only as a matter of curiosity, but as necessary to elucidate the circumstances of family which I have just related, and to explain feelings and sentiments, which might otherwise appear unsuitable and morbid in the character of my brother.

Cornwall was then without great roads. The roads which traversed the country were rather bridle paths than carriage roads; carriages were almost unknown, and carts even were very little used. I have

heard my mother relate, that when she was a girl, there was only one cart in the town of Penzance, and that if a carriage occasionally appeared in the streets it attracted universal attention. Packhorses then were in general use for conveying merchandise, and the prevailing manner of travelling was on horseback. At that period the luxuries of furniture and living, enjoyed by people of the middle class at the present time, were confined almost entirely to the great and wealthy: in the same town, where the population was about 2000 persons, there was only one carpet, the floors of rooms were sprinkled with sea sand, and there was not a single silver fork. The only newspaper which then circulated in the West of England was the Sherborne Mercury, and it was carried through the country, not by the post, but by a man on horseback specially employed in distributing it. At that time, when our colonial possessions were very limited, our army and navy on a small scale, and there was comparatively little demand for intellect, the younger sons of gentlemen were often of necessity brought up to some trade, or mechanical art, to which then no discredit, or loss of caste, as it were, was attached. The eldest son, if not allowed to remain an idle country squire, was sent to Oxford or Cambridge, preparatory to his engaging in one of the three liberal professions of divinity, law, or physic; the second son was perhaps apprenticed to a surgeon or apothecary, or a solicitor; the third to a pewterer or watchmaker; the fourth to a packer or mercer, and so on, were there more to be provided for. At the same time, the early education of all the sons was similar. They were sent to a grammar-school, and there acquired

in six or seven years a moderate portion of Latin and Greek. After their apprenticeships were finished, the young men almost invariably went to London, to perfect themselves in their respective trade or art, and on their return to the country, when settled in business, they were not excluded from what would now be considered genteel society. Visiting then was conducted differently from what it is at present. Dinner parties were almost unknown, excepting at the annual feast time. Christmas, too, was then a season of peculiar indulgence and conviviality, and a round of entertainments were given, consisting of tea and supper. Excepting at these two periods, visiting was almost entirely confined to tea parties, which assembled at three o'clock, broke up at nine, and the amusement of the evening was commonly some round game at cards, as Pope Joan, or Commerce. The lower class then was extremely ignorant, and all classes were very superstitious; even the belief in witches maintained its ground, and there was an almost unbounded credulity respecting the supernatural and monstrous. There was scarcely a parish in the Mount's Bay that was without a haunted house, or a spot to which some story of supernatural horror was not attached. Even when I was a boy, I remember a house in the best street in Penzance, which was uninhabited, because it was believed to be haunted, and which young people walked by at night at a quickened pace, and with a beating heart. Amongst the middle and higher classes, there was little taste for literature, and still less for science, and their pursuits were rarely of a dignified or intellectual kind. Hunting, shooting, wrestling, cockfighting, generally ending in drunken-

ness, were what they most delighted in. Smuggling was carried on to a great extent, and drunkenness and a low scale of morals were naturally associated with it. Whilst smuggling was the means of acquiring wealth to bold and reckless adventurers, drunkenness and dissipation occasioned the ruin of many respectable families. Mr. Coulson, of Penzance, a man of an inquisitive turn of mind, and of good information, who has favoured me with some remarks on this period, after adverting to this vice and its effects, observes, that "few places have exhibited greater changes than the neighbourhood of Penzance, and that not a single family belonging to the great gentry now in existence west of Hayle, or in the Mount's Bay, was known one hundred years ago." The circumstances just related, relative to Penzance and its neighbourhood, may appear almost incredible to those who are only acquainted with its present state; its population of about 7000 souls, a harbour successively enlarged till it has become a work of great magnitude, generally crowded with shipping; its streets, handsome, and almost entirely newly built, lighted with gas; a public library, a geological and agricultural society*, and a neighbourhood highly cultivated, abounding in garden grounds and gentlemen's villas, with excellent roads in all directions, even to the Land's End, and an ample number of carriages, public and private, of various descriptions. This, its present improved and flourishing condition, it owes to many causes, and chiefly to

* Since the above was written, a Mechanics' Institution has been established, dedicated to the memory of my brother; and another institution, bearing the name of the Penzance Institution, designed to diffuse useful knowledge amongst the people.

those which have operated in England generally during the period under consideration, and have effected throughout the country a similar augmentation of wealth, and in many particulars an amelioration of circumstances. The tide of change and of improvement began to flow about the period that my brother was born, and it doubtless had a powerful influence on his destiny; in fact, he plunged into its current, conscious of his own powers and fitness to move in it, and advanced on its wave.

My brother was born on the 17th of December, 1778, at five o'clock in the morning, in a house in which our parents then resided in Market Jew Street, the first street on entering Penzance from the eastward. He was christened on the 22d of January of the following year, and was nursed by my mother. He was a healthy, strong, and active child, and in every respect forward. It is remembered that he walked off, (to use a nursery phrase,) when he was just nine months old, and I have been told that before he was two years old he could speak fluently. About this time my eldest sister was born, and he was told by a servant, that on her appearance his "nose would be put out of joint." On seeing the baby, it is related of him, that he put his hand to his nose and said, "Mamma, my nose not out of joint." This may seem a very trifling incident, and unworthy of notice; it marks, however, quickness and early attention. Being an only child when he was born, in the midst of many fond relations and kind friends, he was a great favourite, and was made much of, a circumstance no doubt which greatly conduced to the developement of his infant faculties. Before he had learned his letters, he could recite little prayers

and stories, which had been repeated to him, till he had got them by heart; and before he had learned to write, he amused himself with copying the figures in Æsop's Fables, which, with "Pilgrim's Progress," were his first favourite books; and under his drawings in great letters he contrived to give them their names. His memory was very retentive; in proof o. which it is handed down in the family, that when very young he could recite a great part of the book last mentioned, even before he could well read it. I believe that, like Pope, he "lisped in numbers." I remember hearing my mother say, that when scarcely five years old he made rhymes, and recited them in the Christmas gambols, attired in some fanciful dress prepared for the occasion by a playful girl who was related to him. His disposition as a child was remarkably sweet and affectionate.

The first school he was sent to was that of a Mr. Bushell, at which reading and writing only were taught. This master, then an old man, remarking the rapid progress of his young pupil, in a very disinterested manner recommended to my father removing him (he was then six years old) to the grammar school. The grammar school was kept by the Rev. Mr. Coryton, a man of irregular habits, and ill fitted for the office of teaching youth, and as deficient in good method as in sound scholarship. He was generally careless, indiscriminating, and indulgent in regard to the manner in which the boys performed their exercises; but occasionally severe, acting the tyrant, and punishing heavily slight offences. Pulling the boys' ears was practised by him in the most capricious manner, and my brother was too frequently a sufferer from this infliction. It is

recorded of him that, on one occasion, he appeared before Mr. Coryton with a large plaster on each ear, and that, when asked by his master what was the matter with his ears, he replied, with a very grave face, that he had "put the plasters on to prevent a mortification." It is curious to see how, in after-life, he reflected on the apparent disadvantages and evils of this school, and supposed that good had accrued to him from them. In a letter to my mother, written in 1802, towards the close of it, making inquiries respecting me, who a short time before had been sent to school at Helstone, he asks, "Does John like Latin and his school, now the novelty of the first impression is passed away? I recollect I was rejoiced when I first went to Truro school, but I was much more rejoiced when I left it for ever. Learning naturally is a true pleasure: how unfortunate then it is that in most schools it is made a pain. Yet Dr. Cardew comparatively was a most excellent master. I wish John may have as good a one. After all, the way in which we are taught Latin and Greek does not much influence the important structure of our minds. I consider it fortunate that I was left much to myself when a child, and put upon no particular plan of study, and that I enjoyed much idleness at Mr. Coryton's school. I perhaps owe to these circumstances the little talents that I have, and their peculiar application. What I am I have made myself; I say this without vanity, and in pure simplicity of heart;" and that it really was so said, is evident from the manner in which it is written at the end of the letter, when he had filled his paper with other matters, and was obliged to write it round the margin.

During the early part of his life, to which he thus refers the formation of the bias of his character, he was more distinguished out of school and by his comrades than by any great advance in learning. Within school the stimulus was wanting to exertion. He appears to have taken the lead in his class, and to have been satisfied; or rather, as it may be inferred from the above, disgusted, with the uninviting form in which classical knowledge was offered to him, and the repulsive circumstances accompanying it. From his facility in composing Latin and English verse, his assistance was often requested, even by boys much older than himself, in these exercises; and in writing valentines and love-letters he shone so pre-eminently, and gave his aid so willingly, that he is said to have been generally resorted to on all emergencies of boyish loves. Another cause of popularity amongst his comrades was his power of diverting them by telling them stories; and so attractive were the stories, commonly of wonder and terror, which he related, that they were in the habit, in an evening, of collecting at a particular place to wait for him, as under the balcony of the Star Inn*, which afforded shelter, and where, if there happened to be a cart, he would get into it and hold forth to his young audience. His stories, greatly embellished by his invention, were collected partly from books, especially the "Arabian Nights," of which he was ever very fond, and partly from old people, with whom he was a great favourite, particularly from his grandmother Davy. She was a woman of a fervid and poetical

* This inn was nearly opposite to the house in which he was born: it has undergone less alteration than most of the houses in the town, and its balcony still remains.

mind, of a very retentive memory, and had at command a rich store of traditions and marvels. His evenings were frequently spent with her, listening to tales of the olden time, and to stories of ghosts, in the apparition of which she had a stedfast belief; and she believed even that she had witnessed them herself in two instances, and that a house, in which she had before lived in Tregony, was a haunted one. I have been told that one evening my brother enacted the part of a ghost by concealing himself in a cupboard, provided with a sheet; and in the dusk, when the old lady was seated by the fireside, he threw open the door and stalked across the apartment. It is remembered also, that when he returned to the room presently after, he had from her an exact account of his successful apparition, with her cool speculations on its import. His other boyish tastes and pursuits, like the preceding, followed him into manhood. Fishing was very early a favourite amusement of his; indeed, his taste for it appears to have been almost instinctive. When a child he used, with a crooked pin tied to a stick by a bit of thread, to go through the movements of the angler, and fish in the gutter of the street in which he lived. Dr. Paris tells a story in illustration of another taste in his boyish days for which he was distinguished in after-life, — that of experimenting, — and how it first appeared in his exhibiting a light within a turnip which he had scooped out, and which he used for the purpose of melting fragments of tin, obtained from the blocks of this metal which are collected quarterly in the market place of Penzance for coinage, or receiving a mark upon them preparatory to their exportation. In regard to the experimental part of the

exhibition I must express myself sceptical, and am disposed to think that it was an addition of the person from whom Dr. Paris obtained his information; for, in the first place, boys are not allowed to take such liberties with the blocks of tin as is supposed; and, in the next, I doubt if the fusion of a fragment of tin could be effected by the means specified. The earliest indication that I am aware of, which he showed of his fondness for experimenting, was in making fire-works. My eldest sister very well remembers, that she was his assistant in this undertaking, and that their workshop was an unfurnished room, in which, in bad weather, the Rev. Dr. Tonkin (the elder brother of the friend of our family), then advanced in age, and a valetudinarian, took exercise on his chamber-horse, a large arm-chair attached to spring boards, which boards served for a table for compounding the ingredients of the squibs and crackers.

The circumstances of his boyish days were equally favourable to health and the formation of active habits, and to the fostering of that love of nature which never forsook him through life, and was an unfailing source of solace and delight to him even in pain and sickness. He took up his abode with Mr. John Tonkin when he was nine years of age, on the occasion of our family leaving Penzance to reside at Varfell, which is situated on the shore of the Mount's Bay, separated from the sea by an intervening marsh, and immediately opposite the most striking and beautiful feature in the Bay, that from which it derives its name, St. Michael's Mount. This romantic object, whether he was at Penzance or at Varfell, was almost constantly in view; and in the

frequent visits which he made to his home, he saw much that could not fail to impress his susceptible mind. The country between Varfell and Penzance, a distance of about two miles and a half, is an exquisite specimen of Cornish scenery: the expanse of the ever-varying blue sea on one side, bounded only by the horizon, and the distant headlands; on the other side, furze-clad hills, and rocky little glens, pouring down transparent tiny streams, diversified with bright green fields, farm-houses, orchards, and all the other accompaniments of cultivation.* These

* The following poetical lines, written by a gentleman of the neighbourhood of Penzance, were intended to be inscribed on a pile of rocks known by the name of Gulval-Carne, situated in one of the most beautiful of the little valleys above alluded to, and which was a favourite haunt of my brother's in early life, and where, after his death, it was proposed to erect a monument to his memory: —

Inscription for the Rocks at Gulval.

These rocks were once the sportive hour's retreat
Of Davy's boyhood. Here his youthful gaze
Fix'd in rapt musing on the shores, the sea,
And on the "fabled Mount," which lifts its tower
Crowning the waters. — Loved, but not indulged,
The dreams of Fancy fled: for strong awoke
Those inborn sympathies, which bade him woo
Philosophy, a helpmate to explore
The depths of Nature, and with chemic skill
To trace the secret powers which mould her forms.
Of human knowledge to enlarge the bounds,
To win new empire for the mind of man,
Ev'n in thy chambers [1], Death, — to him was given.
How few achieve such triumphs! whose rewards,
Unlike the trophies raised by other toils,
By Time are cherish'd, and by Time increased. [2]
Preserve his name, ye rocks: and on your brow,
As with a mother's fond, and fost'ring hand,
Let Nature still her mossy garlands wreathe [3]:
A monument, beyond man's utmost art
To rear; fit object of his tend'rest care
To guard, and save. C. V. L. G.

Nov. 9. 1831.

[1] By his Safety Lamp. [2] See his own thoughts in his Consolations.
[3] "Nec ingenuum violarent marmora tophum."—*Juv. Sat.* 3. 20. See the whole passage.

little journeys to and fro were made on horseback, on a favourite pony, called Derby; and, when he was able to wield a fishing-rod, or carry a gun, he roamed at large in quest of sport over the whole of the adjoining districts,—a region admirably adapted to invite curiosity and affect the imagination,—whether we look to its natural scenery, its antiquities, its venerable Druidical remains, or its great works of mining art. Under the same favourable circumstances, a taste for natural history early appeared in him: he had a little garden of his own, which he kept in order, and he was fond of collecting and painting birds and fishes.

In mentioning these circumstances and incidents of his young life, I would not wish to be considered as attaching much importance to them. Thousands of individuals have been born and brought up amidst similar scenes, and in a manner very little different from him, without being gifted with any unusual abilities; and very many boys have shown indications of precocious talent, superior to his, which has withered in the bud or flower. There belonged, however, to his mind, it cannot be doubted, the genuine quality of genius, or of that power of intellect which exalts its possessor above the crowd, and which, by its own energies and native vigour, grows and expands, and comes to maturity, aided, indeed, and modified by circumstances, but in nowise created by them. We look back on the infancy of the man of genius with a curious and inquisitive eye, and easily discover presages in the actions of the child of the deeds of the man, — actions which, at the moment, attracted little attention, and seemed to be without import, and which owe their interest

solely to the future; and thus I believe it was in my brother's case. He was thought at the time a clever boy, but not a prodigy; and no anticipation was then formed of the high career he was so soon to enter upon, and of the proud distinctions he was about to earn. This very clearly appears from a letter of his last master, Dr. Cardew, to whose school he was removed when he was fourteen years old, on the 15th of January, 1793. Dr. Cardew's words are, — "While he was under my care, he gave me much satisfaction, being always regular in the performance of his duties as a school-boy, and in his general conduct. He was, too, I believe, much liked by his school-fellows for his good humour; but he did not at that time discover any extraordinary abilities, or, so far as I could observe, any propensity to those scientific pursuits which raised him to such eminence. His best exercises were translations from the classics into English verse."

His quitting Dr. Cardew's school was an important era in his life; he left it in December, 1793, and then, at the early age of fifteen, his school education was considered as completed, and his self-education, to which he owed almost every thing, was about to commence.*

* I have been favoured with a specimen of his early composition in prose (the earliest remaining), written when he was with Dr. Cardew, and inserted in the school album, which is still in existence. It appears as a fragment; and is on Gratitude in connection with the Supreme Being: —

"Our Creator should be the first object of gratitude, which is due to him for all his mercies. We should admire, love, and praise him. Indeed, we can never make sufficient return for his goodness: the least thing we can do is to be grateful; yet we seldom consider him as the dispenser of the blessings we enjoy; we rather attribute it to ourselves. Yet if he were to withdraw the least of his favours, we should think him unjust. Man seldom or never thinks himself obliged

Immediately on his return to Penzance, he took up his abode with his kind friend Mr. John Tonkin, by whom he had been, in a manner, adopted, and who defrayed his expenses during the twelve months that he was at Truro. The greater part of the following year he was, I believe, in an unsettled state, studying in a desultory manner, by fits and starts, and yielding to the allurements of occasional dissipation, and the amusements which constitute the delight of active youth, as fishing, shooting, swimming, and solitary rambles. This, perhaps, was the most dangerous period of his life, and in conversation with me he has so spoken of it. Amusement, for a time, threatened to obtain the mastery, and keep him down to the common level. But his good genius triumphed; and, after a few months vacillation, he applied himself in earnest to the cultivation of his mind, and to the acquisition of knowledge; and the flame, once kindled, burnt ever after, till it expired in death. His exact course of study, after leaving school, I have not been able to ascertain, except that he commenced by taking lessons in French with a Mr. Dugart, a refugee, who resided at Penzance; nor have I been able to learn if any peculiar circumstances influenced him, besides the workings of his own mind and an aspiration after better things, to relinquish all his idle and boyish habits. About this

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to his Maker; he makes a god of his own desires, and adores them instead of the Deity. We should think ourselves obliged to a person who snatched us from impending danger, or relieved us from distress: how much more grateful ought we to be to him who protects us every day from imminent danger, and desires nothing for his goodness but gratitude and praise? A grateful heart is more acceptable to the Lord than a multitude of sacrifices."—*H. Davy.*

period his father's health was declining; and in December of that year (1794) he died. This event probably had a powerful effect in giving steadfastness to his resolution; and, I am quite certain, that the circumstances of his family became with him an additional and powerful motive to exertion. Another circumstance, which immediately followed, might have aided the impression of the last: I allude to the choice of a profession.

In the beginning of the following year, namely, on the 10th of February, 1795 (the date of his indenture), he was apprenticed to Mr. Bingham Borlase, a man of talent, then practising as surgeon and apothecary in Penzance, who afterwards received a diploma, and was distinguished as a physician.

His note-books, commenced about this time, which have been preserved, and which are now before me, show the ardour with which he entered upon his studies, and the extensive reach of his mind in the various branches of knowledge which he proposed to pursue.

The earliest of them, bearing the date of this year, is, on many accounts, a literary curiosity. It is a small quarto, with parchment covers: on one of the covers, on the outside, is the figure of an ancient lyre, drawn with his pen, and, on the other, an olive wreath encircling a lamp; as if in anticipation of his great discovery of confining flame in the safety lamp. At the commencement of it is the following plan of study, which I shall transcribe verbatim:—

1. Theology.
   Or Religion, } - { taught by Nature.
   Ethics, or moral virtues } - { by Revelation.
2. Geography.

3. My Profession.
    1. Botany.
    2. Pharmacy.
    3. Nosology.
    4. Anatomy.
    5. Surgery.
    6. Chemistry.
4. Logic.
5. Language.
    1. English.
    2. French.
    3. Latin.
    4. Greek.
    5. Italian.
    6. Spanish.
    7. Hebrew.
6. Physics.
    1. The doctrines and properties of natural bodies.
    2. Of the operations of nature.
    3. Of the doctrines of fluids.
    4. Of the properties of organised matter.
    5. Of the organisation of matter.
    6. Simple Astronomy.
7. Mechanics.
8. Rhetoric and Oratory.
9. History and Chronology.
10. Mathematics.

To give some distinct idea of the bent of his studies at this time, I shall notice briefly the principal topics which appear in this MS. volume. It opens with "Hints towards the Investigation of Truth in Religious and Political Opinions, composed as they occurred, to be placed in a more regular manner hereafter." His first essay is "On the Immortality and Immateriality of the Soul;" the second bears the title of "Body, organised Matter;" and his third is "On Governments." Then there follows:—"On the Credulity of Mortals;" next, "An Essay to prove that the Thinking Powers depend on the Organisation of the Body;" next, "A Defence of Materialism;" next, "An Essay on the ultimate End of Being;" next, "On Happiness;" then, "On Moral Obligation." These topics occupy rather more than one half of the book; the other part, which appears to have been written after, commences at the opposite end, inverted. The subjects treated of occur in the following order:—"Theology;" "The Christian Religion not repugnant to true Philosophy;" "An Essay on the In-

fluence of Climate on national Manners and Happiness;" "On Friendship, an Essay;" and besides these, which are the principal contents of the book, there are some verses, and the beginning of a romance, called "*An Idyl*," in prose, in the form of dialogue; the characters, "Trevelis, a warrior, and friend of Prince Arthur, and Morrobin, a Druid;" the scene, "a cliff at the Land's End, in Cornwall, and the time, night."

This mere enumeration of topics strongly marks the early bias of his mind; and the manner in which he treated the subjects was very characteristic; first, I would say, of that period of his life, and next, of himself. This I shall illustrate by some extracts. Even the partial display of the workings of such a mind may be interesting, and not without advantage to others. He starts in his career of inquiry devoting himself to unprejudiced reason, which is to be his sole guide. With all the daring confidence of youth, he enters upon the most difficult problems in metaphysics and theology, and employing a syllogistic method of reasoning, in somewhat of a mathematical form (which, as he observes in his "Consolations in Travel," young men commonly follow in entering upon such inquiries), he arrives, as might be expected, at conclusions contrary to the good feelings and common sense of mankind. It will suffice to give an example of the arguments from which he deduces inferences in favour of materialism. He says, "If we trace the progress of the thinking powers from their original source, we shall find that they owe their being to perception. A child, when it first comes into the world, is without ideas, and, consequently, he does not think. All the actions he

performs arise from instinct. When hunger calls him, he satisfies his cravings with the milk of his mother; nor does he at all differ from the most stupid animal, only in being more helpless. He possesses but a small degree of perception; his attention is awakened with difficulty; the memory is weak and faint; and the ideas, without being often repeated, are not retained. As the child advances in years, the nerves become firmer and the brain stronger; perception is quicker, and the memory is more tenacious and retentive. Judgment, the result of perception and memory, is displayed: by degrees reason as slowly advances; and, lastly, disposition, the boundary of human intelligence, appears. Gradual is the progress of mind from sense to science. When the mental faculties have reached their highest perfection in manhood, they gradually decline; and nought is left of all the wreck of human knowledge but pure sensation, a principle gradually decaying with the falling frame. From hence there follows a self-evident corollary, that the thinking powers are not always the same: whatsoever is not always the same is naturally changeable, is mortal and material. Besides, we have traced the power of thinking from 0 to 0, increasing with the corporeal powers, and decreasing and ending with them."

In this cold region of materialism, which was altogether uncongenial to a mind like his, he remained a very short time. The same reasoning power which entangled him in the difficulty, when more exercised and strengthened, freed him from the thraldom. Intent on truth, he always had a wonderful facility in relinquishing an opinion, and this in metaphysical inquiries as well as in the pursuits of science; and

thus, by not being too much "devoted to consistency" (to use an expression of his own), he was able to advance in the line of discovery. There are before me now observations of his in this note-book, written, apparently, after looking over his former sentiments, and comparing them with those which he entertained at the moment. At the bottom of a portion of his first essay, in which he considers the reasons for and against the immateriality of the soul, he has written, "These observations were written at sixteen years and a half: what a revolution in my opinions since that time, now nineteen years and a half."

In the same note-book, under the head of "The Christian Religion not repugnant to true Philosophy," he writes, "A very short time since, I should have considered nothing more unlikely than my defending religion."

I shall now insert some passages from the same note-book, illustrative of this change of sentiment from materialism, and probably scepticism, if not irreligion, to a rational religious belief founded on immaterialism. I shall first give the heads of a train of argument in favour of the latter doctrine.

"1. The power of thinking does not naturally belong to matter.

"2. Motion, if ever so artfully distributed, it is plain, can produce nothing but motion.

"3. Matter acts only in proportion as it moves; thinking is acting without motion; *ergo*, that which thinks is not matter.

"4. The universality of the hypothesis.

"5. Internal consciousness of the existence of a monadic indivisible soul."

I shall next give some extracts, conveying his views on religion, which, though contained in this note-book, were probably formed a year or two later.

"THEOLOGY.

"All religion arises from a belief in a Supreme Being, the maker of, and the directing cause that governs, the universe. To prove, then, the necessity of religion, it will be first of all necessary to prove the existence of such a being. Things must have been in their present situation, either from the agency of such a being, or from chance.

"1. From the consideration of final causes, there arise a thousand arguments to prove the being of a God.

"2. Then, if matter is naturally inanimate, motionless, and disorganised, it would have ever continued so, without some cause to set it in motion.

"3. If every part of matter had been naturally inclined to motion, the world would have been a universe of dancing atoms, without regularity.

"One or other of these it must have been; chance could have had no influence either in one or the other.

"Or supposing it had an influence on the last, it could never have produced regular systems, formed according to the nicest rules of geometry: it could never have produced organised systems capable of thinking.

"If chance could not have made the world what it is, and as matter is naturally motionless, it necessarily follows, that there must have been some cause which set it in motion, powerful, active, and intelligent. This cause having endowed particular masses of

matter with particular properties,—having made them active, intelligent, and powerful, and having given them means to increase their powers and happiness by many extraordinary benefits and advantages not common to being in general,—it follows that they ought to adore, and be thankful to him for these properties, which is the foundation of natural religion."

A little further on are sketched the heads of an Essay, bearing the title of, "The Christian Religion not repugnant to true Philosophy."

"1. Introduction. Of the Nature of Evidence. Distinction between Faith and Knowledge.

"2. Nature of the Evidence for Christianity.

"3. Christianity consistent with Theism. Deism the Religion of Jesus Christ.

"4. The Necessity of Revelation proved.

"5. The Difficulty of gaining the Knowledge of the Unity of the Godhead without Revelation.

"6. The God of the Bible, and the Morality of the Bible, consonant with Reason and Nature.

"7. Objections answered."

I cannot find that he completed or continued this essay; nor have I been able to find any thing on the subject of religion in any other of his early note-books, excepting in one, which, from the handwriting, it may be inferred, was in use about the same time as the preceding, and which contains "A Letter on the pretended Inspiration of the Quakers and other Sectaries." In it are many forcible remarks on the subject of illusions in matters of religion, and on the influence of enthusiasm and superstition, "passions" (he justly observes) "which, though seemingly opposite, are often found in the

same person, and domineer over the mind alternately." After showing the tendency of the human mind to error from its very nature, and to deceive itself and others, mistaking the illusions of fancy for realities, and the hallucinations of a distempered intellect for heavenly inspirations; and after pointing out the usefulness of "a moderate degree of rational scepticism," as a guard against these sources of error, he concludes with observing, that "the simple and fundamental truths of the Christian religion are perfectly intelligible; viz., the unity of God; the necessity of morality; and the future state of retribution founded on the resurrection." And these, he adds, "should be made the basis of our faith, for they will bear the test of reason, and stand firm and immutable amidst the eternal revolutions of opinion."

It is interesting to compare these his early inquiries on the subject of religion with those he engaged in at a later period, as expressed in his "Salmonia," and "Consolations in Travel." We may trace in the former the germs of many of the latter; and, indeed, the resemblance is often so marked, that the trains of thought have very much the character of recollections; with this marked difference, however, that in youth he considered reason as all-sufficient, whilst in later life he mistrusted it, as inadequate, and built his faith on internal or instinctive feeling, rather than on any process of ratiocination. And, I may here further remark, that, in comparing the two periods of his life, in relation to this inquiry, it is instructive to witness how presumptuous and daring is youthful genius; how easily satisfied with the semblance of truth;

how modesty, distrust, and humility increase with the acquisition of knowledge; and how, with the conviction of the very limited extent of human knowledge, religious hope and faith also increase.

For the purpose of illustrating, as fully as is in my power, the other studies which he engaged in at this time, and his modes of thinking and feeling, I shall not hesitate to make further extracts from his note-books, which are the more interesting and worthy of credit, as they were intended solely for his own use, and contain, it may be said, the spontaneous effusions of his mind, "written in rough," as he expressly states. I shall limit these references, in this place, to the period of about three years and a half, at the expiration of which he left Penzance for Bristol.

During the first year, that is 1795, from the contents of his earliest note-books already given, it would appear that his studies, though miscellaneous, were chiefly metaphysical, connected with religion; and that neither his profession, nor any branch of physical science, had yet become the subject of decided preference. This is well shown in his essay "On the Influence of Climate on National Manners and Character." It is ingeniously written, and displays very considerable reading, and much discrimination, but not a proportional knowledge in matters of science, and especially of chemical science. Indeed, there is a remark in it, which pretty clearly indicates, that when he wrote it he was ignorant of the merest rudiments of chemistry; for, speaking of the climate of Egypt, he attributes the coolness of the nights there "to the great quantity of nitre with which the air is impregnated."

The "Essay on Friendship," which follows that on climate in the note-book, marks also the nature of his miscellaneous studies. It is chiefly deserving of notice, however, as it displays the generous sentiments which he entertained at this period on the subject of friendship, and which he retained and cherished throughout life. I shall make a quotation from it, without hesitation on account of its length, believing that it will excite a sympathy in every ingenuous mind.

"Friendship," he says, "derives all its beauty and strength from the qualities of the heart, or from virtuous or lovely dispositions; or, should these be wanting, some shadow of them must be present: it can never dwell long in a bad heart or mean disposition. It is a passion limited to the nobler part of the species, for it can never coexist with vice or dissimulation. Without virtue, or the supposition of it, friendship is only a mercenary league, or a tie of interest, which must of course dissolve when that interest decays, or subsists no longer.

"It is a composition of the noblest passions of the mind: a just taste and love of virtue, good sense, a thorough candour and benignity of heart, and a generous sympathy of sentiment and affections, are the essential ingredients of this nobler passion. When it originates from love and esteem, is strengthened by habit, and mellowed by time, it yields infinite pleasure, ever new and ever growing. It is the best support amongst the numerous trials and vicissitudes of life; and gives a relish to most of our enjoyments. What can be imagined more comfortable than to have a friend to console us in afflictions, to advise with in doubtful cases, and

share our felicity? What firmer anchor is there for the mind, tossed like a vessel on the tumultuous waves of contingencies, than this? It exalts our nobler passions, and weakens our evil inclinations; it assists us to run the race of virtue with a steady and undeviating course. From loving, esteeming, and endeavouring to felicitate particular people, a more general passion will arise for the whole of mankind. Confined to the society of a few, we look upon them as the representatives of the many, and from friendship learn to cultivate philanthropy."

He finishes this essay with an allegory, intended to illustrate the influence of friendship, "in its tenderest form, between the sexes" (his own words), and how much their happiness depends upon mutual love and esteem. The Almighty is described, after the creation of man, as deliberating with the guardian angels of his throne, on the propriety of creating woman. Justice, Peace, and Virtue, personified in these angels, plead against her creation, on the ground of the vice and misery she is likely to bring on her companion, who, on her account, will be "driven from Paradise, and happiness, and joy, to labour in pain and misery on the barren earth."

They are met by intercessors, by Mercy and Religion, who plead in her favour, and by Divine Love:—"The Omnipotent hesitated; when his first-born child, the divine Love, stood before him; her countenance covered with smiles ineffably pleasing. 'Create her,' she cried, 'for Paradise itself will afford no delight to man without woman. She will be the cause of his misery, but she will likewise be the cause of all his happiness. She will console him in affliction; she will comfort and har-

monise his soul; she will wipe the tears from his eyes, and compose the fury of his passions. Her friendship shall make him virtuous, and her love shall make him happy; and, lastly, the tree of their transgression, and the plant of immortality, nourished by the blood of her son, shall flourish, and grow out of paradise, and overspread the earth: man shall eat of their fruit, and be immortal and happy."

There is poetry in this prose; and the same note-book contains proofs, that, whilst his judgment and reasoning powers were unfolding, his imagination was kindled; and, what is very unusual in youth, his fancy was not depressed by the severer faculties, but merely guided, sustained, and strengthened. Knowledge, in fact, was the food of his imagination, and, even his earliest poetry, displays a strong tincture of philosophy, and not less of a love of nature; indeed, these two, a philosophical spirit, and an intense love of nature, happily blended in his poetical writings, impart to them a peculiar character, and give them their principal charm. And all the allusions to nature, even at this early period, as well as at a later, betoken the strong impression of the actual scenery before his eyes, and express the great features of the scenes surrounding him. In confirmation, I shall insert here one of his earliest poems entire, which was first published in the "Annual Anthology" of 1799, with the date of 1795, when it was probably conceived, and perhaps written in part, though I believe it was not completed till a year or two after.

" THE SONS OF GENIUS.

" Bright bursting through the awful veil of night
The lunar beams upon the ocean play;
The watery billows shine with trembling light,
Where the swift breezes skim along the sea.

" The glimmering stars in yon ethereal plain
Grow pale, and fade before the lurid beams,
Save where fair Venus, shining o'er the main,
Conspicuous still with fainter radiance gleams.

" Clear as the azure firmament above,
Save where the white cloud floats upon the breeze;
All tranquil is the bosom of the grove,
Save where the zephyr warbles through the trees.

" Now the poor shepherd wandering to his home,
Surveys the darkening scene with fearful eye, —
On every green sees little elfins roam,
And haggard sprites along the moonbeams fly.

" While superstition rules the vulgar soul,
Forbids the energies of man to rise,
Raised far above her low, her mean control,
Aspiring genius seeks her native skies.

" She loves the silent, solitary hours;
She loves the stillness of the starry night,
When o'er the bright'ning view Selene pours
The soft effulgence of her pensive light.

" 'Tis then, disturb'd not by the glare of day,
To mild tranquillity alone resign'd,
Reason extends her animating sway
O'er the calm empire of the peaceful mind.

" Before her lucid, all-enlightening ray,
The pallid spectres of the night retire;
She drives the gloomy terrors far away,
And fills the bosom with celestial fire.

" Inspired by her, the sons of genius rise
Above all earthly thoughts, all vulgar care;
Wealth, power, and grandeur, they alike despise, —
Enraptured by the good, the great, the fair.

" A thousand varying joys to them belong, —
The charms of nature and her changeful scenes:
Theirs is the music of the vernal song,
And theirs the colours of the vernal plains.

" Theirs is the purple-tinged evening ray,
With all the radiance of the evening sky;
Theirs is the splendour of the risen day,
Enshrined in glory by the sun's bright eye.

"For them the zephyr fans the odorous dale;
For them the warbling streamlet softly flows;
For them the Dryads shade the verdant vale;
For them sweet Philomel attunes her woes.

"To them no wakeful moonbeam shines in vain
On the dark bosom of the trackless wood;
Sheds its mild radiance o'er the desert plain,
Or softly glides along the crystal flood.

"Yet not alone delight the soft and fair,
Alike the grander scenes of nature move;
Yet not alone her beauties claim their care,
The great, sublime, and terrible they love.

"The sons of nature,—they alike delight
In the rough precipice's broken steep;
In the bleak terrors of the stormy night;
And in the thunders of the threatening deep.

"When the red lightnings through the ether fly,
And the white foaming billows lash the shores;
When to the rattling thunders of the sky
The angry demon of the waters roars;

"And when, untouch'd by Nature's living fires,
No native rapture fills the drowsy soul;
Then former ages, with their tuneful lyres,
Can bid the fury of the passions fall.

"By the blue taper's melancholy light,
Whilst all around the midnight torrents pour,
And awful glooms beset the face of night,
They wear the silent, solitary hour.

"Ah! then how sweet to pass the night away
In silent converse with the Grecian page,
Whilst Homer tunes his ever-living lay,
Or reason listens to the Athenian sage.

"To scan the laws of Nature, to explore
The tranquil reign of mild Philosophy;
Or on Newtonian wings sublime to soar
Through the bright regions of the starry sky.

"Ah! who can paint what raptures fill the soul
When Attic freedom rises to the war,
Bids the loud thunders of the battle roll,
And drives the tyrant trembling from her shore?

"From these pursuits the sons of genius scan
The end of their creation,—hence they know
The fair, sublime, immortal hopes of man,
From whence alone undying pleasures flow.

"By Science calmed, over the peaceful soul,
Bright with eternal Wisdom's lurid ray,
Peace, meek of eye, extends her soft control,
And drives the puny Passions far away.

"Virtue, the daughter of the skies supreme,
Directs their life, informs their glowing lays;
A steady friend, her animating beam,
Sheds its soft lustre o'er their latter days.

"When life's warm fountains feel the frost of time,
When the cold dews of darkness close their eyes,
She shows the parting soul upraised, sublime,
The brighter glories of her kindred skies.

"Thus the pale moon, whose pure celestial light
Has chased the gloomy clouds of heaven away,
Rests her white cheek, with silver radiance bright,
On the soft bosom of the western sea.

"Lost in the glowing wave, her radiance dies;
Yet, while she sinks, she points her lingering ray
To the bright azure of the orient skies,
To the fair dawning of the glorious day.

"Like the tumultuous billows of the sea
Succeed the generations of mankind;
Some in oblivious silence pass away,
And leave no vestige of their lives behind.

"Others, like those proud waves which beat the shore,
A loud and momentary murmur raise;
But soon their transient glories are no more,
No future ages echo with their praise.

"Like yon proud rock, amidst the sea of time,
Superior, scorning all the billow's rage,
The living sons of genius stand sublime,
The immortal children of another age.

"For those exist whose pure ethereal minds,
Imbibing portions of celestial day,
Scorn all terrestrial cares, all mean designs,
As bright-eyed eagles scorn the lunar ray.

"Theirs is the glory of a lasting name,
The meed of genius, and her living fire;
Theirs is the laurel of eternal fame,
And theirs the sweetness of the muse's lyre."

From the same source of information, his note-books, it appears that in the beginning of the following year, namely, 1796, he entered on the study

of the mathematics. One book is almost entirely confined to this subject; and in it, his progress may be traced through the following branches, which he enumerates under the head of "Mathematical Rudiments;" viz., "Fractions, vulgar and decimal; Extraction of Roots; Algebra (as far as quadratic equations), Euclid's Elements of Geometry; Trigonometry; Logarithms; Lines and Tangents; Tables; Application of Algebra to Geometry, &c." He entered upon Fractions, February 8th, 1796; and he appears to have finished the elementary course which he assigned himself in little more than twelve months, for the last date is January 2. 1797, when he was commencing the eleventh book of Euclid, and he had gone through most of the other branches.

In this study he was very systematic; the propositions are all entered very neatly, and the demonstrations given; the diagrams are invariably done with a pen, without the aid of mathematical instruments, not even of a common compass and ruler, except in one or two instances. This circumstance of itself would show that he engaged in these studies without a master, which was the fact, and perfectly voluntarily on his part, from the conviction of their usefulness preliminary to the study of physical and chemical science.

His favourite pursuit and exercise of mind this year and the following, as also during the preceding, was metaphysics, on which he has left very copious notes. These rough notes display much thought, and some original thought, and an acquaintance with the writings of all the more distinguished metaphysicians of modern times, as Locke, Hartley, Bishop Berkeley, Hume, Helvetius, Condorcet, Reid, and his

followers, who are designated by the general title of the Scotch metaphysicians; and he appears to have had some acquaintance with the doctrines of Kant and the Transcendentalists. Even now he thought for himself, and seems to have been free from the undue influence of authority. When he mentions distinguished names, it is not in the way of simple assent to their opinions, but critically, and often in terms of dissent. Thus, on the subject of ideas, he admits, with Locke, that what are commonly called innate ideas are words without meaning; but he does not admit that the mind of the new-born child is a *tabula rasa;* he contends that, even in the womb, it may have acquired ideas of touch and of hearing, and that, even before birth, thought may have been exercised. In illustration of his modes of thinking at this time, I shall give a few passages which occur in his note-book detached.

"Human life is nothing more than a succession of sensations, ideas, pleasures, and pains. Science or knowledge is the association of a number of ideas, with some idea or term capable of recalling them to the mind in a certain order."

"By examining the phenomena of nature, a certain similarity of effects is discovered. The business of science is to discover these effects, and to refer them to some common cause; that is, to generalise ideas."

"Far from being conscious of the existence of matter, we are only conscious of the active powers of some being. By discovering the ratio between the attraction and repulsion of external things and our organs, we should discover philosophy."

About this time, or perhaps a little later,—certainly

whilst he was at Penzance,— he commenced a work, which he intended to have been of a comprehensive kind and considerable length, but which, like all his other exercises of mind at this period, was unfinished. It was called "Observations relating to Existence:" I shall notice briefly some parts of it. The first division of it was "On the Use of Words," in which he points out the idols of language, and how the idolatry of words has infected all discussions as concerning space, identity, spirit, substance, matter, &c. He says, "The science of the human mind, or existence, is nothing more than the formation of an intelligible language, in which a simple history of the existence and arrangement of impressions, ideas, or feelings is communicated." The second division is "On Innate Ideas," to which I have already referred. Opposing the notion of the child being born with its mind blank, he remarks, "If a child is capable of hearing external noises in the womb, he may, probably, have some collections of ideal terms in his mind before birth; they can, however, have no *accurate* meaning, but they may have meaning, because they may be associated with other ideas. When considering this subject, he observes, "What are called reasonings, moral truths, and self-evident propositions, are neither more nor less than collections of general terms standing for other terms, which themselves stand for ideas." The third division is "On Consciousness," and the fourth, "On the Arrangement of Beings," with which the fragment terminates as a connected dissertation.

His metaphysical studies were associated with some professional ones. Those of which he left any memoranda were chiefly theoretical, relating to physiology,

in which he pursued a path similar to that he first followed in metaphysics and religon,—being a process of abstract reasoning founded on a few principles, or abstract terms, by which, like Hartley and Brown, he attempted to explain all the phenomena of life. But his illusion was of short duration; he very soon discovered the fallacy of the method, and ever after completely avoided it.

His passion for poetry appears to have kept pace with the expansion of his faculties, and not to have been damped even by application to the mathematics; but all his efforts in numbers this year were desultory, if I may judge from the remains of them, and confined principally to brief effusions, expressive of some particular sentiment or feeling. I shall give only one specimen, the concluding part of a small poem called "The Tempest," which was published in the "Annual Anthology" of 1799, with the date of 1796:—

"THE TEMPEST.

"For the bright blushing morning, all rosy with light,
Shall convey on his wings the Creator of day;
He shall drive all the tempests and terrors of night,
And nature, enliven'd, again shall be gay.

"Then the warblers of spring shall attune the soft lay,
And again the bright flowret shall blush in the dale;
On the breast of the ocean the zephyr shall play,
And the sunbeam shall sleep on the hill or the vale.

"If the tempests of Nature so soon sink to rest;
If her once faded beauties so soon glow again;
Shall man be for ever by tempests oppress'd,—
By the tempests of passion, of sorrow, and pain?

"Ah, no! for his passions and sorrows shall cease,
When the troublesome fever of life shall be o'er;
In the night of the grave he shall slumber in peace,
And passion, and sorrow, shall vex him no more.

"And shall not this night, and its long dismal gloom,
Like the night of the tempest again pass away?
Yes! the dust of the earth in bright beauty shall bloom,
And rise to the morning of heavenly day."

In the following year (1797) he appears to have commenced in earnest the study of natural philosophy. The bias of his former speculations followed him here, as his note-books show, in which there are some theoretical views and reasonings respecting impulse, and the communication of motion; and further on this subject, or on the collision of bodies, I suspect his inquiries did not extend. Dr. Paris, from some information which he received from my brother's early friend and schoolfellow, the Rev. Dr. Batten, fancies that he had made a series of experiments to investigate the laws of the collision of bodies, by means of elastic and inelastic balls. This conclusion I am disposed to consider unfounded: amongst his memoranda there is no allusion to any such experiments, nor did I ever hear him speak of them. He was fond of billiards, and for a short time after leaving school indulged in the game, as I have heard him mention, when speaking of that dangerous period of his life. At the billiard table, I would conjecture he collected the data, on which the speculations on collision were founded, with which he surprised his friend. Be this as it may, the pursuit of natural philosophy soon gave place to that of chemistry. He began the study of chemistry in November or December of the same year, when he was just entering on his nineteenth year. Several incidents, which will be mentioned hereafter, enable me to fix the time with precision. He appears to have entered on this study merely as a branch of his professional knowledge, and to have followed it at

first chiefly theoretically. His early chemical reading was confined to two works of a very different description, — " Lavoisier's Elements of Chemistry," and " Nicholson's Dictionary of Chemistry,"—the one distinguished for its admirable logic, precision of reasoning, and boldness of speculation compared with any that had preceded it; the other an indifferent collection of facts and opinions, of various times and merit, — a kind of border tract between the old and new doctrines, and hardly worthy of the name of the author it bore. This new study seems very soon to have excited in his mind a most lively interest. He was not satisfied with merely reading, and acquiring the ideas of others; he criticised the theoretical views of the great French philosopher; doubted, rejected, and advanced speculations of his own. And speculation appears to have led him to experiment, and experiment to further speculation, with such rapid progress, that in a few months he formed a new hypothesis, and flattered himself that he had triumphed over an important part of the doctrine of the French school. Such was the commencement of his career of original research, which in a few years, by a succession of discoveries, accomplished more in relation to change of theory and extension of science, than in the most ardent and ambitious moment of youth he could either have hoped to effect, or could have imagined possible.

I could wish to dwell on his early chemical studies and pursuits, and relate all the circumstances of them minutely; but I regret to say that I have very little information to give respecting them. That the theoretical parts of chemistry first engaged his attention, will presently appear from his own words.

It is, however, equally certain, both from his own statements, and from the recollection of his family, that he did not confine himself to speculation, and that he very soon entered on a course of experiments. His means, of course, were very limited; not more extensive than those with which Priestley and Scheele began their labours in the same fruitful field. His apparatus, I believe, consisted chiefly of phials, wine glasses, and tea cups, tobacco pipes, and earthen crucibles; and his materials were chiefly the mineral acids and the alkalies, and some other articles which are in common use in medicine. He began his experimental trials in his bed-room in Mr. Tonkin's house, in which, as already stated, he was a favourite inmate. Here there was no fire, and when he required it, he was obliged to come down to the kitchen with his crucible. Dr. Paris, in describing this period of his life, and the imaginary shifts he was driven to for apparatus, indulges in some facetiousness respecting a syringe forming part of a case of instruments which, according to his story, a shipwrecked French surgeon, in gratitude for attentions, gave my brother, and which was converted by him into a pneumatic apparatus. The details of the new application of this instrument are given by Dr. Paris, with a minuteness and vivacity worthy of De Foe, as if he himself had been a spectator of what he describes. Notwithstanding, I believe the story to have been altogether an invention; and, as Dr. Paris states that he had it from Mr. Giddy, Mr. Giddy probably had it from some facetious person, who wished to amuse him. This I infer, because no one belonging to our family ever before heard of this instrument, or of the French surgeon, or of the shipwrecked

French vessel off the Land's End, so circumstantially noticed in Dr. Paris's lively narrative.

The experiments, I believe, which my brother first engaged in, were of a simple kind; as the preparing of the gases, trying the effects of acids and alkalies on vegetable colours; the solution and precipitation of metals; in brief, those required to illustrate the leading doctrines of the science, and to exhibit the most remarkable then known of its agents. But to these alone he did not long confine himself; very soon he originated new experiments, for the purpose of supporting his speculative views, or of ascertaining the truth of his opinions. The number, however, of these, I believe was not large; and I infer this from his own statements, and from not being able to find in his note-books of the time any minutes of experiments, — only hypothetical views and arrangements.

The rapidity with which he advanced in his new pursuit is strongly indicated by the circumstance that, in the April following, in the short space of four months, he was in correspondence with Dr. Beddoes, relative to his researches on "Heat and Light," and a new hypothesis on their nature, to which Dr. Beddoes became a convert. The results of these researches were the chief subject of his first publication, "Essays on Heat and Light," &c., which were in part written a few months after he had commenced the study of chemistry. I shall have occasion to revert to them particularly further on, when the time in which they were finished and published comes under consideration; viz., the year 1799.

The very rapid advance I have described was, no doubt, principally owing to the enthusiasm

with which he prosecuted the science, and applied to it all the powers of his mind: but it was also favoured and promoted by circumstances. These I shall briefly notice, and one especially, which was his becoming acquainted with Mr. Gregory Watt. This gentleman came to Penzance in the winter of 1797, and remained there during the following spring; and, fortunately for my brother, became a lodger in my mother's house, boarding with the family. He was then in his twenty-first or twenty-second year, as I have learned from his brother, Mr. James Watt. He had left the University of Glasgow a short time before; his mind, enriched beyond his age with science and literature, with a spirit above the little vanities and distinctions of the world, devoted to the acquisition of knowledge. Of a mild and amiable disposition, in familiar intercourse with the family with whom he lived, he and my brother speedily became acquainted, and their acquaintance soon ripened into friendship of the warmest and most disinterested kind. They met daily; explored the objects worthy of notice in the adjoining country; visited the most remarkable mines, and, as my sister well remembers, generally returned from their walks with their pockets loaded with specimens of rocks and minerals. The Wherry mine, the shaft of which was in the sea, approached by a long wooden bridge, and the workings of which were entirely under the sea, at the short distance of about a mile from Penzance, was a favourite place of resort with them. It afforded an unusual variety of minerals*, and, from its peculiarities, could

* In a paper by my brother on the Geology of Cornwall, published in the first volume of the Transactions of the Royal Geological Society of Cornwall, this variety is called by him "extraordinary." He says,

not fail to excite a deep interest in their minds, as a struggle of art against nature, in which a victory was gained over the elements by means of the most wonderful invention of the age,—the steam-engine, —which, only a short time before, had been perfected by the distinguished father, the elder Mr. Watt; and this very engine, erected on the shore, acting at a distance over the surface of the sea, and drawing up water from beneath its bed, was one of the earliest that had been introduced into Cornwall.*

The precise advantages which my brother derived from these excursions and daily communings cannot be calculated. The information he obtained was doubtless one, but I suspect a very small one, in comparison with another: I mean the sympathy which the generous friendship of youth, so suitable to genius, is ever ready to yield, and the consciousness of intellectual power and resources, which must naturally result from the struggle of intellect.

If this meets the eye of any reader of Dr. Paris's work, a marked difference will be perceived between his account and that which I have given of the manner in which this acquaintance was formed. I think it right to revert to Dr. Paris's, because I do not consider it just to either party. He speaks of Mr. Gregory Watt as possessing "a solemn aristo-

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"I have seen in the refuse heaps, blende, oxide of uranium, oxide of titanium and of iron; peach blende, nickel, and arsenical pyrites; and in a single piece of the vein of a few inches square many of these substances might be found embedded in quartz or chlorite."—P. 42.

* For a description of this remarkable mine, I may refer the reader to Mr. John Hawkins's paper on submarine mines, published in the same volume of the work last quoted. Mr. Hawkins remarks, that "the close of this mine was as romantic as its commencement. Its machinery was destroyed by a vessel which broke from its anchorage in the adjoining roadstead, and ran against it."—P. 142.

cratic coldness of manner, which repulsed every approach to familiarity;" and of my brother as "not possessing any of those qualifications in person or manner which are calculated to produce favourable prepossessions;" adding, that he sought to ingratiate himself with Mr. Watt by metaphysical discussions, but, instead of admiration, he excited the disgust of his hearer," &c. Dr. Paris does not state how he obtained this information, which, indeed, from the manner in which it is delivered, so dramatic and precise, one might suppose he owed to his own personal knowledge, and that he was actually present, and saw and heard what he describes: but that was impossible. No doubt he has been misled by some one, who was no friend to either individual, and capable of sacrificing truth for the sake of the ludicrous. The "solemn aristocratic manner" attributed to the one, as little belonged to him as "pertness" did to the other. The manner of Mr. Gregory Watt, I have been informed by those that knew him, was simple, mild, and kind; and that of my brother, I have been assured, was in nowise deficient in youthful modesty or grace; and further on, when it will be my duty to repel similar aspersions, I shall bring forward evidence in proof of what I have stated.* Some respect is due to genius,—the illustrious dead should not be spoken of by scoffing tongues,—justice at least is due to them. If an author is cursed with a prurient pen, let him direct it against the living, who can

* Mr. Gregory Watt's surviving brother, Mr. James Watt, in a letter now before me, addressed to John Craig, Esq., says, "I do not think, speaking from the recollection of my impressions, and those of some mutual friends of my brother and Sir Humphry, that the published accounts have done full justice to the first intercourse between them."

reply. Unfortunately, it too frequently happens that the person who is capable of traducing departed worth, as unblushingly flatters living power. Unfortunately, too, whenever dirt is thrown, some of it will adhere, "*calumniare audacter aliquid adhærebit;*" and it is painful to think that it can only be washed away by the stream of time, which, whilst it purifies, destroys.

To return to my subject.—Another favourable circumstance, though less to be insisted on, was the acquaintance which my brother about the same time formed with Mr. Davies Gilbert (afterwards his successor in the chair of the Royal Society), a man older than himself, with considerable knowledge of science generally, and with the advantages of a university education. The manner in which they became acquainted requires to be mentioned, as it, too, has been misrepresented and placed in a ludicrous point of view by Dr. Paris. It was briefly thus:— My brother, at this time, when prosecuting his chemical inquiries, begged of Mr. John, a gentleman of great respectability, and one of the oldest inhabitants of Penzance (who is my authority), to witness some experiment. He good-naturedly looked at it, remarking, at the same time, that he did not understand these things, but that there was a friend of his who did, and that the experiment should be shown to him. This was Mr. Gilbert (then Mr. Davies Giddy), to whom Mr. John took an opportunity of introducing my brother. It is not necessary to particularise Dr. Paris's narration of their meeting, written with the same levity and desire to excite a laugh as the one preceding; but I do consider it right to endeavour to correct the exaggerated

manner in which he speaks of my brother's obligations to Mr. Gilbert, which I cannot help thinking must be distressing to Mr. Gilbert himself. The advantages derived from his acquaintance were similar to those experienced from the friendship of Mr. Gregory Watt — such as result from scientific and literary intercourse, which, though mutual, may be differently estimated according to the feelings of the individuals concerned, and their respective grade in society. More substantial benefits, I believe, Mr. Gilbert never conferred on my brother, except in facilitating the arrangements connected with his first scientific appointment. If his expressions of gratitude were to be taken as the measure of his obligations, it might be supposed that, throughout life, he was under obligations to most of his correspondents. He was always thankful for kindness, which was with him an obligation.

In considering the very rapid progress of my brother in chemical science, other circumstances, besides the acquaintance of Mr. Gregory Watt and Mr. Davies Gilbert, may be briefly noticed: even the locality of his native town was favourable to it. The surrounding mines of copper and tin, abounding in a great variety of splendid and extraordinary minerals, worked to vast depths by means of the power of water and steam; the adjoining cliffs and headlands, composed of rocks strikingly different, from the granite of the Land's End to the serpentine of the Lizard; and even the sea and air of that tempestuous and ever-changing climate, could hardly fail to rouse the curiosity of his active intellect, and to excite a strong desire to study the science which promises to explain the mysterious

operations of nature. And, when he did begin the study of it, these sources yielded him subjects in abundance to experiment on, and bring into play his powers of research; even the weeds thrown up by waves on the sea-shore, or vegetating in the pools of salt water on the ebbing of the tide, afforded matter for interesting inquiries, and were, indeed, one of the first objects, if not the very first, to which he applied himself in the way of original research.

Moreover, the state of the science at that time was very favourable to his rapid advances in it: a new theory of chemistry, the antiphlogistic, only a few years before had been brought forward, and was hardly yet fully established; pneumatic chemistry was a recent acquisition, and its distinguished discoverers were still flourishing; analytical chemistry, and chemistry applied to nature and the arts, were even less advanced: in brief, the known boundaries of the science were of small extent, the knowledge of it easily acquired, and in every direction unexplored regions tempted enterprise and ambition.

Nor is it undeserving of mention, that the course of study which he himself had followed previous to his entering on chemistry was well adapted to aid in the acquisition of the latter: in fact, it was just that course which, in his posthumous work in the dialogue called the "Chemical Philosopher," he recommends as a preparatory one. From his school education he had acquired a tolerable knowledge of Latin and Greek; after leaving school, he had learned French so as to read works in that language with perfect facility, and to speak it fluently (though not with a good pronunciation; for his master was a

Breton); he had mastered the rudiments of the mathematics; his mind had been exercised in metaphysical discussion; and his reading had been more extensive than most people would imagine, either considering his youth, or what might be supposed the means within his reach. There is now before me a list of books, which he read before quitting Penzance; it is furnished by Mr. Coulson from his own knowledge. In this list are enumerated "Locke's Essays—Reid's, and Stewart's, Enfield's History of Philosophy, Rollin's Ancient History, Gibbon's Decline and Fall of the Roman Empire, History of Modern Europe, Hume's Essays and History, Thomson's Seasons, Milton, and Shakspeare." Besides these, there were many other works which he perused, both of science, literature, and poetry, either belonging to his family, or borrowed from his friends, or got from a book club in Penzance, which, I believe, was formed after he had become acquainted with Mr. Davies Gilbert, as this gentleman was also a subscriber to it.

Lastly, it may be remarked, his professional pursuits accorded with his chemical, and even promoted them. This was a circumstance of some importance, inasmuch as he could conscientiously devote a considerable portion of his time to his favourite science without any feeling of impropriety, with the conviction, that the knowledge he was so assiduously gaining might be of the greatest use to him, both in the study and practice of the healing art.

How he conducted himself during his apprenticeship, as a student of medicine and as an assistant of his master, now requires to be mentioned. It would appear that he applied himself with earnest zeal to

all his professional studies and duties, and that he gained equally the good opinion of Mr. Borlase and of his patients, especially of the poorer class, to whom he showed particular kindness. Mr. Borlase's high opinion of him, and estimation of his deserts, was proved by an act of generous kindness, which will be noticed in its place; and this gentleman's sister, Mrs. Foxell, bears testimony to the humane way in which he behaved towards those in humbler life. She has told my sister, that, "in all cases of distress, she used to call upon him, and always found him ready to render every assistance in his power; and that she had often heard him say that he wished to make himself useful to his fellow-creatures." My eldest sister, who was only two years younger than my brother, in her recollections of him (which, at my request, she has committed to paper), speaking of the manner in which he was considered at this time, especially by Mr. Borlase's family, and by poor patients,—after noticing that he was a great favourite with the old Mr. Borlase, the venerable father of Dr. Borlase, with whom he often sat up at night during his last illness, who liked to receive all his medicines from his hands, and on whose countenance, however much in pain he might be, and impatient, the sight of him was sure to produce a smile,—adds, "All the family loved and respected him: indeed, I may say he was beloved by all who had the happiness of knowing him. Many poor people whom he attended speak of him with respect, gratitude, and affection; he not only relieved their wants as much as lay in his power, he also sympathised in their afflictions." She further adds, "I believe I mentioned to you a poor soldier he

attended, who had been neglected by his surgeon. The poor man's head was in a dreadful state: nothing but great humanity, and a wish to relieve the sufferings of a fellow-creature, could have induced him to dress it every day." And she remarks, immediately after, "I have often heard my mother say, that from a child he had a most feeling heart."

Of the exact nature and extent of his medical studies I am not able to give a precise account. Mr. Borlase was much above the level of country practitioners in general, both in professional and literary attainments; it may be fairly inferred that he would give all the instruction in his power to his favourite pupil. His collection of medical works was, I believe, pretty extensive and good; and to these alone my brother's reading was not confined: he used freely the books which belonged to his friend Mr. John Tonkin, and he had probably the use of Dr. Tonkin's library, not to mention some medical and surgical works which had belonged to a Mr. John Davy, a surgeon, and a near relation. His progress in his profession must have been considerable, as when he went to Bristol, in the fourth year from the commencement of these studies, he was considered competent by Dr. Beddoes to take charge of the patients belonging to the Pneumatic Institution.

Though intensely devoted to study and the acquisition of various knowledge, he did not, however, give up shooting and fishing. With his gun and dog (an excellent water spaniel, called Chloe *), he

* This favourite dog is well remembered in Penzance. Having been taken from her mother as soon as born, with the greater part of the litter, she was about to be drowned. He begged the gift of her,

often went to the adjoining marshes, where he became a proficient in snipe shooting; or to the more distant covers in the warm valleys frequented by the woodcock *, a kind of shooting of which he was ever afterwards extremely fond. His fishing excursions were chiefly in spring, when the small streams are in the best state for angling — turbid, in a slight degree, from the mild rains common in April and May. It is remembered how, on the 5th of June, 1797, he and his companion Mr. Leonard Millett, his uncle-in-law, caught seven dozen trouts in a rivulet and mill-pond close to the residence of the Rev. Edward Giddy, Mr. Davies Gilbert's father, in the parish of St. Earth. His early angling was like that of Isaac Walton; he was not then initiated into the nobler mysteries of fly-fishing.

It is stated by Dr. Paris, that he was in the habit of declaiming by the sea side "against the howling of the wind and waves, for the purpose of correcting a defect in his voice, which, although only slightly perceptible in his maturer age, was, in the days of his boyhood, exceedingly discordant." This statement, I believe, is unfounded. I have always heard his voice spoken of as of an agreeable tone, even when he was young. It is true that, like most

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and, by means of great care, reared her. My sister writes, that, "on his first return from Bristol, after an absence of about twelve months, Chloe did not remember him till he called her by name, and then she was in a transport of joy." Her descendants are now numerous in the Mount's Bay, and prized for good qualities.

* At that time, in Cornwall, little attention was paid to the game laws; every one who chose amused himself with a gun, and went in pursuit of the minor caccia, birds of passage, such as the woodcock, snipe, and water-fowl, without any licence, and without apprehension of question.

young persons, he was fond of declaiming, and indulged in it in his walks and solitary rambles. On one occasion, it is recorded of him, that, on his way to visit a poor patient in the country, in the fervour of declamation, he threw out of his hand a vial of medicine, which he had to administer, and that, when he arrived at the bedside of the poor woman, he was surprised at the loss of it. My informant, Mrs. Foxell (to whom he must have related the circumstance), adds, that the potion was found next day in a hay-field adjoining the path.

It is also related by Dr. Paris, that he belonged to a volunteer corps, and that, though he had private lessons from a drill sergeant, he never could emerge from the awkward squad, or learn the platoon exercise. The story is told by Dr. Paris in his usual precise, lively, and comic manner, and the reflection is appended, that "he whose electric battery was destined to triumph over the animosity of nations, never could be taught to shoulder a musket in his native town." The reflection reminds me of the answer of an Irishman, given in a journal kept by my brother during one of his tours in Ireland. "Conversing on the Georgium Sidus, one of the company was asked by another if he was acquainted with astronomy. He replied, 'I dare say I might, had I applied to it, for no one in our village beat me at the manual exercise.'" However, the incongruity charged against my brother is unfounded, and entirely imaginary, as he never was in a volunteer corps.

Another anecdote given by Dr. Paris is correct; viz., that, having been bitten by a dog with the symptoms of hydrophobia, my brother cut out the

lacerated part without hesitation, and applied caustic to the wound in his leg.* This is a striking instance of that mental intrepidity which he possessed, and on many occasions exerted through life — arising, not from boldness of nerve or animal courage simply, but from the control of mind over body. That he believed, at this early period, in the possibility of such a controlling power being exercised, I do not doubt, and who can? but this is very different from a sentiment attributed to him by the same author, on hearsay — "his disbelief in the existence of pain whenever the energies of the mind are directed to counteract it;" a proposition which I have no hesitation in rejecting as his, both because it is illogical, and because it is associated with a ludicrous incident in its enunciation.

This period of his life was, I believe, a very happy one: I mean the last year he spent at Penzance. He had become conscious of his own powers of intellect; he had an enthusiastic delight in the exercise of them; vast fields of unexplored science opened

* He told Mr. Southey, as I have been informed by a friend, that, six months after he was bitten, he felt some of the premonitory symptoms of hydrophobia. These, probably, were sensations which might have occurred to any one, but would not have attracted the attention of any one who had not an apprehension of hydrophobia, and was not anxiously watching his sensations.

I am tempted, through the medium of this note, to give Mr. Southey's impression of my brother's early powers; and I am the more tempted to do so, from the kind manner in which it was expressed. It was in conversation that Mr. Southey gave his opinion. I shall transcribe from my friend's letter, written just after the interview, his words: — "His eyes filled with tears when he said, 'Davy was a most extraordinary man; he would have excelled in any department of art or science to which he had directed the powers of his mind.'" My friend said, "Might he have been a poet?" He replied, "Yes! he had all the elements of a poet. He only wanted the art. I have read beautiful verses of his." He added, "When I went to Portugal I left Davy to revise and publish my poem of Thalaba."

before him. The love of knowledge; the desire of distinction; the hope of benefiting mankind; in brief, every good motive that can act on a generous mind influenced his. Mr. Coulson, who was very intimately acquainted with him at this time, was strongly impressed with the conviction of his great capacity, and also of his nobleness of character. In a paper now before me, written by him, he concludes with observing that, "had he been left to his bent without any disturbing impulse, that is, without the connections which he fell into from his peculiar situation, he would have exhibited to the world a much nobler elevation than even that to which his great powers raised him."

The state of his mind and feelings is pourtrayed in vivid characters in one or two passages which I have found in his note-books kept during this period: —

"I have neither riches, nor power, nor birth to recommend me; yet, if I live, I trust I shall not be of less service to mankind and to my friends than if I had been born with these advantages." And this early sentiment never forsook him: even in his last days he had a feeling of the same kind, looking forward, were his life spared, to greater exertions. Another passage I shall give, which I consider ap-applicable to him, though I am not sure that he wrote it of himself: if the feelings were intended for an ideal character, I have no doubt they had been experienced in great part by himself. It is a fragment amongst fragments: —

"I gradually became conscious of my powers, by comparing them with those of others. That solitary enthusiasm, however, which constituted my inde-

pendence, was never lost. I was no longer anxious to know what others thought of me, and I panted little after the breath of fame. Hence, agitated by no passion but the love of truth, the desire to see things in their real light counteracted every other desire. My conversations were plain and simple; I perceived that circumstances and the developement of my moral powers had produced, or, rather, gradually unfolded, a new moral character. It was this character that I sought to improve, by casting from me every trait of hypocrisy and concealment. I considered all my possible relations with men, and I found no one which could again possibly turn me over to dependence."

It has been already stated, that, in the short space of about four months from the time he commenced the study of chemistry, he was in correspondence with Dr. Beddoes on the subject of heat and light. Soon after, Dr. Beddoes offered him the situation of superintendent of the Pneumatic Institution, which had been established at Clifton for the purpose of trying the medicinal effects of different gases. After some negotiation respecting the terms of the appointment (in which Mr. Davies Gilbert aided him in a very friendly manner), he gladly accepted it, with the consent of all his friends, excepting Mr. John Tonkin (who had hoped he would have settled at Penzance), and with the approval of Mr. Borlase, who (the period of his apprenticeship not being expired), in a very generous manner, released him from "all engagements whatever, on account of his excellent behaviour;" adding, "because, being a youth of great promise, I would not obstruct his present pursuits, which are likely to promote his

fortune and his fame." This I have copied from the back of the indenture now before me, written, and signed by Mr. Borlase on the 1st of October, 1798. On the following day he left his home, to enter upon his public career, before he was twenty years old. Even at this time, when starting in life, the objects of science were a main consideration with him; and the expectation of having ampler means for indulging his love of inquiry was, I believe, the chief temptation which prevailed with him to quit Penzance, and the prospects which he there had of moderate independence. In a letter to Dr. Beddoes, written when the engagement was concluded (of which I find a portion of the rough draught in one of his note-books), he says, "I have now made all the experiments I can make *here*: a very short time will arrange and collect them; but this I can do better at Clifton than at Penzance."

The undertaking which he entered upon with such motives was with him eminently successful, though with an ordinary person it would have proved a failure. If the Pneumatic Institution had any reputation, it was owing to his exertions in its cause; if it was of any service to medicine or science, it was chiefly through his instrumentality; and, however useful Dr. Beddoes was to him, he was more so to Dr. Beddoes. In this instance, as in most others, the obligations he received produced a fruitful return.

CHAPTER II.

ADVANTAGES OF HIS SITUATION AT CLIFTON. — VERSES ADDRESSED TO MRS. BEDDOES, — TO HER INFANT DAUGHTER. — LETTER TO HIS MOTHER ON QUITTING HOME. — HIS ESSAYS ON HEAT AND LIGHT. — DISCOVERY OF SILEX IN THE EPIDERMIS OF GRASSES. — PURSUITS, CHEMICAL AND LITERARY, AT THIS PERIOD OF HIS LIFE. — HIS RESEARCHES, CHEMICAL AND PHILOSOPHICAL, CHIEFLY CONCERNING NITROUS OXIDE AND ITS RESPIRATION. — LETTERS TO HIS FAMILY. — REVISITS HOME. — LINES ON THE OCCASION. — EXTRACTS FROM HIS NOTE-BOOKS, SHOWING HIS VARIED PURSUITS, AND MODES OF SENTIMENT AND THOUGHT. — FRAGMENTS OF A POEM. — HAPPY LIFE AND ASPIRATIONS. — ROYAL INSTITUTION OF GREAT BRITAIN. — LETTER TO HIS MOTHER ON AN OFFERED APPOINTMENT IN IT, WHICH HE ACCEPTS.

The period of my brother's life on which we are now about to enter, that which he spent at Clifton, is the most important in relation to himself, if not the most interesting in his eventful career. If the situation he had accepted of superintendent of the Pneumatic Institution had been created purposely for him, it could not have been more suitable to the bent of his genius, or better adapted for calling into activity and developing fully the powers of his mind; and the collateral circumstances generally were not less auspicious. The society he mixed with, Dr. Beddoes's family, of which he became an inmate, and even the scenery by which he was surrounded, all contributed to exercise a favourable influence over him.

The Pneumatic Institution owed its rise to Dr. Beddoes. It was supported entirely by subscription; the subscribers to it were chiefly liberal men of science, and the intention of founding it was to

afford an opportunity of giving a fair trial to the medicinal effects of the different gases, with the sanguine hope then indulged in, started and supported by Dr. Beddoes, that powerful remedies might be found amongst them; that diseases hitherto bidding defiance to medical art, by means of them might be cured or relieved; and that, in the investigation of their operation, light would be thrown on many obscure parts of physiology, to the great benefit of medical science, both in regard to practice and theory. Such was the design of the institution, which was to be provided with all the means likely to promote it — an hospital for patients, a laboratory for experimental research, and a theatre for lecturing.

Dr. Beddoes himself was a very remarkable man, admirably fitted to promote inquiry, better than to conduct it. To give the reader an insight into his character, I shall introduce here a sketch of him, written by my brother in the last year of his life, when, a valetudinarian, he amused himself with looking back on his old friends and acquaintances, and in describing the most distinguished of them: —" Beddoes was reserved in manner, and almost dry; but his countenance was very agreeable. *He was cold* in conversation, and apparently much occupied with his own peculiar views and theories. Nothing could be a stronger contrast to his apparent coldness in discussion, than his wild and active imagination, which was as poetical as Darwin's. He was little enlightened by experiment, and, I may say, little attentive to it. He had great talents, and much reading, but had lived too little amongst superior men. On his death-bed he wrote me a most affecting letter, regretting his scientific aberrations. I remember one

expression: 'Like one who has scattered abroad the *avena fatua* of knowledge, from which neither branch, nor blossom, nor fruit has resulted, I require the consolations of a friend.' Beddoes had talents which would have exalted him to the pinacle of philosophical eminence, if they had been applied with discretion."

Dr. Beddoes's family was a very agreeable one: it owed its chief charm to its mistress. Mrs. Beddoes I have always heard spoken of as a very delightful person, especially by my brother, who had a sincere regard and esteem for her, and ever after a grateful feeling of her kindness. Beauty, virtue, grace, wit, judgment, and knowledge appear to have been combined in admirable harmony in this charming woman. I will not deprive myself of the pleasure of inserting here a copy of verses addressed to this lady, written by him some years after: there is this brief notice attached to them:—"Glenarm, August, 1806, by moonlight, a view of the cliff and sea." They record powerfully her beneficial influence over his mind, and are a beautiful and touching tribute to her worth, and a testimony of virtuous friendship:—

"Think not that I forget the days,
When first, through rough unhaunted ways,
We moved along the mountain side,
Where Avon meets the Severn tide;
When in the spring of youthful thought
The hours of confidence we caught,
And Nature's children, free and wild,
Rejoiced, or grieved, or frown'd, or smiled,
As wayward fancy chanced to move
Our hearts to hope, or fear, or love.

"Since that time of transient pleasure
Eight long years have fill'd their measure,
And scenes and objects grand and new
Have crowded on my dazzled view;—

Visions of beauty, types of heaven,
Unask'd-for kindness freely given;
Art, Nature, in their noblest dress,—
The city and the wilderness;
The world in all its varying forms,
Contentments, clouds, ambition's storms.

"Yet still in such a busy scene,
And such a period pass'd between,
The recollections never die
Of our early sympathy:
And in the good that warms my heart
Your friendship bears a living part;
With many a thought and feeling twined
Of influence healthy, noble, kind;
Virtues from your example caught,
And without saws or precept taught.

"The proof this tranquil moment gives
How vivid the remembrance lives;
For e'en in Nature's forms I see
Some strong memorials of thee:
The autumnal foliage of the wood,
The tranquil flowing of the flood,
The down with purple heath o'erspread,
The awful cliff's gigantic head,
The moonbeam on the azure sky,
Are blended with thy memory."

I will also indulge myself with giving another copy of verses, on the infant daughter of his friends Dr. and Mrs. Beddoes, in whom I hope all the wishes he expresses have been realised:—

"Sweet blossom of the early spring of life,
Thy opening lineaments in hope I view;
And as I think on thy maturer age,
I form a fairy dream, and wish it true.

"I see those cheeks now pale as are the clouds
Which in the water'd vale at evening lie,
Kindling with rosy hues of happy health,
And glowing like th' autumnal evening sky.

"I see those locks that now have scarcely reach'd
Thy forehead's smoothness, and thy neck of snow,
In darkest hues of beauty's contrast clad,
In graceful ringlets down thy shoulders flow.

"I see those eyes, which now impassive gaze,
Beaming with softness and unchanging light,
Kindling with holy feeling's brilliant rays,
And in expression's liquid lightnings bright.

"I hear the accents which thy infant voice
Essays in murmurs of imperfect art,
Expressing, in the clearest, sweetest tones,
Thy father's mind, and all thy mother's heart."

The society of Clifton at this time, of which Dr. Beddoes's house may be considered as the gathering point, was more literary and intellectual than usual. Many men of genius resided there, or in Bristol, or made it a place of frequent resort. The most distinguished amongst the number, Mr. Southey, Mr. Coleridge, and Mr. Tobin, had very little the advantage of my brother in age; they were entering with eager emulation on the course of glory; he formed their acquaintance and obtained their friendship; and though the great objects of his pursuit were of a scientific nature, yet he found time to take a part with them in labours purely literary.

As the reputation of the Pneumatic Institution increased, men of rank and science, from various motives, either of health or curiosity, visited it from a distance, and afforded him an opportunity of forming many valuable acquaintances. I shall mention only one in particular, Mr. Poole, of Nether Stowey, in Somersetshire, whose acquaintance with him began here, and soon ripened into a friendship, cherished by both ever after, and the memory of which is still dear to the survivor.

Having made these observations on the circumstances of his new situation, I shall now enter in more minute detail into his history; and to give the reader an idea of his first impressions on coming out

into the world, I here transcribe a letter which he wrote to his mother soon after his arrival at Clifton, trusting that no one will criticise as a literary composition what was a hasty effusion, intended solely for a mother's reading. It is happily descriptive of the joyous state of a youthful mind, of its surprise at new objects, and the facility with which it is pleased: —

"October 11th, 1798. Clifton.

"My dear Mother,

"I have now a little leisure time, and I am about to employ it in the pleasing occupation of communicating to you an account of all the *new* and *wonderful* events that have happened to me since my departure.

"I suppose you received my letter, written in a great hurry last Sunday, informing you of my safe arrival, and kind reception. I must now give you a more particular account of Clifton, the place of my residence, and of my new friends, Dr. and Mrs. Beddoes, and their family.

"Clifton is situated on the top of a hill, commanding a view of Bristol and its neighbourhood, conveniently elevated above the dirt and noise of the city. Here are houses, rocks, woods, town and country in one small spot; and beneath us, the sweetly flowing Avon, so celebrated by the poets. Indeed, there can hardly be a more beautiful spot: it almost rivals Penzance, and the beauties of Mount's Bay.

"Our house is capacious and handsome; my rooms are very large, nice and convenient; and, above all, I have an excellent laboratory. Now for the inhabitants, and, first, Dr. Beddoes, who, between you

and me, is one of the most original men I ever saw—uncommonly short and fat, with little elegance of manners, and nothing characteristic *externally* of genius or science; extremely silent, and, in a few words, a very bad companion. His behaviour to me, however, has been particularly handsome. He has paid me the highest compliments on my discoveries, and has, in fact, become a convert to my theory, which I little expected. He has given up to me the whole of the business of the Pneumatic Hospital, and has sent to the editor of the Monthly Magazine a letter, to be published in November, in which I have the honour to be mentioned in the highest terms. Mrs. Beddoes is the reverse of Dr. Beddoes—extremely cheerful, gay, and witty; she is one of the most pleasing women I ever met with. With a cultivated understanding, and an excellent heart, she combines an uncommon simplicity of manners. We are already very great friends. She has taken me to see all the fine scenery about Clifton; for the Doctor, from his occupations and his bulk, is unable to walk much. In the house are two sons, and a daughter of Mr. Lambton, very fine children, from five to thirteen years of age.

"I have visited Mr. Hare, one of the principal subscribers to the Pneumatic Hospital, who treated me with great politeness. I am now very much engaged in considering of the erection of the Pneumatic Hospital, and the mode of conducting it. I shall go down to Birmingham to see Mr. Watt and Mr. Keir in about a fortnight, where I shall probably remain a week or ten days; but before then you will again hear from me. We are just going to print at Cottle's, in Bristol, so that my time will be much taken up, the ensuing fortnight, in preparations for the press. The theatre for lecturing is not yet open; but, if I

can get a large room in Bristol, and subscribers, I intend to give a course of chemical lectures, as Dr. Beddoes seems much to wish it.

"My journey up was uncommonly pleasant; I had the good fortune to travel all the way with acquaintances. I came into Exeter in a most joyful time, the celebration of Nelson's victory. The town was beautifully illuminated, and the inhabitants loyal and happy. I was so pleased with Mr. Russel and his family, and some other of the inhabitants to whom I was introduced, as to stay there two days, which I chiefly spent with Mr. Russel. The morning after the illumination I rode round Exeter with Mr. Russel, and was wonderfully delighted with the country, which is the most beautiful and the most highly cultivated of any I have yet seen.

"It will give you pleasure when I inform you that all my expectations are answered, and that my situation is just what I could wish. But, for all this, I very often think of Penzance and my friends, with a wish to be there: however, that time will come. We are some time before we become accustomed to new modes of living and new acquaintances.

"Believe me, your affectionate Son,

"HUMPHRY DAVY."

Let us follow him now in his pursuits. The first labour he engaged in when he was established at Clifton, which requires to be particularly noticed, was the finishing and putting in order for publication his researches on heat and light, already more than once alluded to. They were given to the public in the form of essays, in a miscellaneous volume, edited by Dr. Beddoes, in 1799, called

"Contributions to Physical and Medical Knowledge, principally from the West of England;" and were named "Essays on Heat and Light, and the Combinations of Light; with a new Theory of Respiration; on the Generation of Oxygen Gas, and the Causes of the Colours of organic Beings. By Humphry Davy." They extended to 205 pages, and were dedicated to Dr. Beddoes and to the subscribers to the Pneumatic Institution.

As his first publication, they require particular notice, and the more so, as they are in many respects peculiar. The very title of the essays, I may remark, is not uncharacteristic of them. They are the bold attempts of an original and enterprising mind, and bear the stamp, at the same time, of youth and of genius, in the faults of the one, and the redeeming qualities of the other. They are marked by invention, by a certain strength and logical precision of reasoning power, and by much ingenuity both of ideas and experiments; and they are also marked by the want of caution, and the precipitancy of a very young man, which sometimes appears as a defect of modesty.

In a former part of this work, when specifying the time and circumstances under which my brother commenced the study of chemistry, I promised to bring forward proofs of the statement which I then made; and I shall do so now, for they are connected with these essays. Dr. Beddoes, in a paper "On the Arrangement of Bodies according to their Principles," in the same volume, declares himself a convert to my brother's "discoveries" (so he calls them); and adopts even the nomenclature which he had proposed. The following passage in this paper, though

long, is too important in relation to the object I have in view to be withheld:—

Dr. Beddoes says, "Long before I was acquainted with those discoveries or Count Rumford's experiments on friction, I had expunged the *matter of heat*, or caloric, from my chemical system; and on this occasion it is but justice to attest, that the author of the former derived no assistance whatever from the Count's ingenious labours. My first knowledge of him arose from a letter written in April 1798, containing an account of his researches on heat and light; and his first knowledge of Count Rumford's paper was conveyed by my answer. The two essays contain proofs enough of an original mind, to make it credible that the simple and decisive experiments on heat were independently conceived. Nor is it necessary, in excuse or in praise of his system, to add, that, at the time it was formed, the author was under twenty years of age, pupil to a surgeon-apothecary, in the most remote town of Cornwall, with little access to philosophical books, and none at all to philosophical men." And this statement of Dr. Beddoes is confirmed by remarks which I have found in my brother's note-books. In August, 1799, he writes, "About twenty months ago, I began the study of chemistry. The system of Lavoisier, almost the only elementary book in my possession, was the first that I studied. In that system, an imaginary being, called caloric, engaged my attention. I considered he had too much neglected light; and this great source of our sensations engaged my attention," &c. And in the same note-book, just before, alluding to these essays, and the manner in which they were attacked by the reviewers, he writes, "These critics

perhaps do not understand that these experiments were made when I had studied chemistry only four months, when I had never seen a single experiment executed, and when all my information was derived from Nicholson's Chemistry, and Lavoisier's Elements."

Having premised thus much in relation to the circumstances under which these essays were written, I shall now endeavour to give the reader some idea of them, and, by means of extracts, some notion of his style of writing at this early period.

After having made some general remarks on the progress of scientific discovery, and the increasing energy of the human mind in the pursuit of science, he commences in an impressive manner the subject of his inquiry: —

"Light," he observes, "has been heretofore little considered in chemical theory: its affinities have never been investigated. A substance of the greatest importance to organic existence has been very little regarded but in a physical view, as a stimulus, and as the source of the most numerous and pleasurable of our sensations.

"The planetary motions, those wonderful phenomena, and the laws by which they are governed, appear to be designed for the express purpose of supplying the whole of the solar system with a certain necessary quantity of light.

"The general analogy of nature, the wonderful simplicity of causes, and the complexity of effects, would alone tend to prove that this substance is subservient to other purposes than those of vision and vegetation. Since light and heat are usually concomitant, since there is rarely a considerable degree of the one without the other, philosophers have

questioned whether they are not cause and effect; and M. Lavoisier is one of these philosophers. He says, ' La lumière est-elle une modification du calorique, ou bien le calorique est-il une modification de la lumière?' I have made an experiment, which seems to demonstrate directly that light is not a modification or an effect of heat.

" Experiment I.—A small gun-lock was procured, armed with an excellent flint. This lock was elevated, by means of two iron springs, on the stand of the receiver of an air-pump. A slight iron wire was affixed to the trigger, brought through a hole made in the centre of the stand, and cemented into the hole with wax, so as to exclude entirely atmospheric air from the receiver. The receiver was exhausted, and the lock snapped, but no light was produced. The receiver was filled with carbonic acid, and the lock again snapped with the same result: no light was produced. Small particles were separated from the steel, which, on microscopic examination, evidently appeared to have undergone fusion."

He adds, reasoning on this result,—

" If light was a modification, or an effect, of heat, it must have been produced in this experiment, since the heat generated by collision was sufficient to fuse steel;" and he concludes,—

" Light, then, cannot be caloric in a state of projection, but matter of a peculiar kind, capable, when moving through space with the greatest velocity, of becoming the source of a numerous class of our sensations."

From light he proceeds to the phenomena of repulsion in opposition to those of attraction, and

endeavours to prove that there is no more reason for the one class of phenomena depending upon a material principle than the other, and that the existence of a specific matter of heat, called caloric, is assumed and imaginary.

I must refer the scientific reader to the essay itself for the arguments which he brings forward against this doctrine, and which he supports by some very ingenious experiments, referred to by Dr. Beddoes as similar to Count Rumford's on the same subject, and which have not yet been answered in a satisfactory manner by those who maintain the substantial nature of heat.

He next treats of light as a peculiar substance; in its sensible state endowed with a high degree of repulsive motion, and yet subject to the laws of attraction in common with other species of matter, by means of which it enters into combination with them,—loosely in those bodies which are phosphorescent,—intimately with one body, namely, oxygen. This compound of light and oxygene is supposed capable of combining unaltered with some bodies, as nitrogen, muriatic acid, and certain metals; and to be decomposed by other bodies, which it is supposed, on uniting with the oxygen, separate the light, giving rise to the phenomena of combustion. This portion of the essay extends from page 39. to 127., and is very remarkable both in regard to the experiments, speculation, and reasoning. In further illustration, I shall make a few more extracts from it, and chiefly from the speculative parts, as most characteristic. At page 46. he makes some bold conjectures respecting the identity of light and the electric fluid. He says, "The electric fluid is pro-

bably light in a condensed state; that is, not supplied with the repulsive motion sufficient to give it repulsive projection. Its chemical action upon bodies is similar to that of light; and, when supplied with repulsive motion by friction, or the contact of bodies from which it is capable of subtracting it, it takes the repulsive projectile form, and becomes perceptible as light. It is extremely probable that the great quantity of this fluid almost every where diffused on our earth is produced from the condensation of light, from the subtraction of its repulsive motion by black or dark bodies. This fluid, continually formed from the condensation of light, is probably again supplied with repulsive motion at the poles, by the revolution of the earth on its axis, and given off in the form of repulsive projectile light; whilst a quantity equal to that given off from its equilibrating principle is supplied continually from other parts of the globe. Hence the phenomena of the aurora borealis, or northern lights. No more sublime idea can be formed of the motions of matter, than to conceive that the different species are continually changing into each other. The gravitative, the mechanical, and the repulsive motions appear to be continually mutually producing each other, and from these changes all the phenomena of the mutation of matter probably arise."

In the following page he asks, "Is not the blue colour of the air a proof that the repulsive motion of light is diminished in passing through it?—May not the atmospheric temperature, and the refraction of light through it, be in a great measure owing to the water held in solution by the air?"—an inference now generally admitted. At page 36. he considers

hydrogen and nitrogen gas as "probably metals in the state of elastic vapour." At page 68. and 97. he points out some of the incongruities of the Lavoisierian hypothesis of combustion; for example, instances of the condensation of gases in entering into chemical union with diminution of capacity for heat, *without* the production of heat; and, *vice versâ*, the conversion of solids into elastic fluids, as in the decomposition of the detonating compounds, with increase of capacity for heat, *without* the production of cold, but, on the contrary, the production of heat.

At page 127. he supposes that light enters into the composition of living bodies, is essential to their well-being, and is derived by means of respiration. He supposes that phosoxygen (light and oxygen) is not decomposed in the lungs, but combines there with venous blood, whilst carbonic acid and water are liberated. This view of respiration he supports by various experiments, and connects with speculations of a very lofty kind — speculations which, considered merely as such, are deserving rather of praise for their boldness and originality, than of the censure which has usually been bestowed on them: portions of them may be deserving of insertion. At page 140. he asks, "May we not venture to reason on the important and constant change effected in the brain and nerves by the phosoxydated blood? Is it not probable that the existence of some fine ethereal principle in the brain and nerves is the immediate cause of sensitive or perceptive action? If such a fluid exists, it must be continually supplied by the arterial blood, and constantly expended in sensible action." This idea, I may observe, he never totally relinquished, and it appears in his last work

as well as his first. In the "Consolations in Travel," in the Fourth Dialogue, when on the subject of respiration, after having given an account of the appreciable chemical changes belonging to this function, he proceeds, — "But it is probable that this is only a secondary object, and that the change produced by respiration on the blood is of a much more important kind" (that is, than the mere separating of a certain quantity of carbonaceous matter). "Oxygen, in its elastic state, has properties which are very characteristic: it gives out light by compression, which is not certainly known to be the case with any other elastic fluid, except those with which oxygen has entered, without undergoing combustion; and, from the fire it produces in certain processes, and from the manner in which it is separated by positive electricity, in the gaseous state, from its combinations, it is not easy to avoid the supposition, that it contains, besides its ponderable elements, some very subtile matter, which is capable of assuming the form of heat and light. *My idea* is, that the common air inspired enters into the venous blood entire in a state of dissolution, carrying with it its subtile or ethereal part, which, in ordinary cases of chemical change, is given off; that it expels from the blood carbonic acid gas and azote; and that, in the course of the circulation, its ethereal part, and its ponderable part, undergo changes which belong to laws that cannot be considered as chemical: the ethereal part probably producing animal heat and other effects, and the ponderable part contributing to form carbonic acid and other products. The arterial blood is necessary to all the functions of life, and it is no less connected with the irritability of the

muscles and the sensibility of the nerves, than with the performance of all the secretions."

Dr. Paris, giving an account of these essays, advances a very similar opinion on the use of respiration, and even calls it his own. His words are, "Is it unreasonable to conclude that some principle is thus imparted, which is too subtile to be long retained in our vessels, and too important to be dispensed with even for the shortest period?" And he adds, as if entirely ignorant of these essays, "I offer this opinion, as Montaigne says, not as being good, but as being my own!" *

My brother concludes his first essay with the following remarks: — "We may consider the sun and the fixed stars the suns of other worlds, as immense reservoirs of light, destined by the great *Organiser* to diffuse over the univere organisation and animation. And thus will the laws of gravitation, as well as the chemical laws, be considered as subject to one great end — *perception.* Reasoning thus, it will not appear improbable that one law alone may govern and act upon matter, — an energy of mutation impressed by the will of the Deity, — a law which may be called the law of animation, tending to produce the greatest possible sum of perception, the greatest possible sum of happiness.

The further we investigate the phenomena of nature, the more we discover simplicity and unity of design: an extensive field for sublime investigation is open to us. The laws of perceptive life as yet are but partially known: our sensations, ideas, pleasures, and pains depend upon causes now un-

* "The Life of Sir Humphry Davy," 4to, p. 50.

known to us. We cannot entertain a doubt but that every change in our sensations and ideas must be accompanied with some corresponding change in the organic matter of the body. These changes experimental investigation may enable us to determine: by discovering them we should be informed of the laws of our existence, and probably enabled, in a great measure, to destroy our pains and increase our pleasures. Thus would chemistry, in its connection with the laws of life, become the most sublime and important of all sciences."

His second essay, "On the Generation of Oxygen, and the Cause of the Colours of Organic Beings," requires to be noticed but briefly. It may be considered as an appendix to the first essay; an amplification of a part of it, giving in detail a series of experiments on the effects of solar light on terrestrial, marine, and aquatic plants under various circumstances; confirming the results of preceding inquirers that vegetables, whether growing in the atmosphere, or in the still lake, or the disturbed shallows of the sea, or rapid river, acted on by light, have the power of decomposing carbonic acid and disengaging oxygen, and of thus counteracting and balancing the effects of the respiration of animals and of combustion, and of preserving the air of the atmosphere, and that which is dissolved in the water of the ocean, in a uniform wholesome state, best adapted for animal and vegetable life.*

* An ingenious inquirer, Mr. Ellis, has expressed doubt of the general purifying influence of vegetation on the atmosphere; that is, whether growing plants do not rather vitiate the air in a greater degree by combining with a portion of its oxygen, than purify it by the decomposition of carbonic acid in the sap, and the liberation of oxygen, under the operation of light on the green leaf. Such a doubt appears

This investigation, like the preceding, was commenced at Penzance, and finished at Bristol. It was one of the first subjects of inquiry, if not the very first, which he attemped to elucidate by experiment; and it appears that his earliest experiments were made on marine plants, having been led by analogy to infer that they perform in the sea the same part for aquatic animals that terrestrial plants had previously been supposed to do for land animals — the important part of renovating the oxygen consumed in the function of respiration; and the confirmation of this analogy was, I believe, the first discovery he made in chemical science.

The latter part of this second essay on the causes of the colours of organic beings may be considered as a third appendix to his first essay, in which he more minutely examines the effects of light in relation to the colours of plants and animals; and, by experiment and observation, arrives at the conclusion that light is mainly concerned in the evolution of colour, both in the vegetable and animal kingdom. This is, at least, the inference which he draws, but

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to me incompatible with several circumstances. I will not dwell on experiments, though they appear to me conclusive against such doubt; I particularly allude to the experiments of M. de Saussure, many of which I have repeated with the same results, on the effect of healthy vegetation continued for several days, attended with increase of oxygen in the air: I would rather dwell on the immense accumulations of carbon, as exhibited in forests and peat-mosses, and beds of coal of decidedly vegetable origin. How could these accumulations have taken place, excepting by the decomposition of carbonic acid derived from the atmosphere, brought down dissolved in rain or dew? These great experiments of Nature, without presumption, may be said to exclude all doubt. The accumulation of so much carbon in a vegetable, whether in the lichen on the rock destitute of soil, or in the forest tree, growing in a soil enriched with vegetable matter by the fall of the leaf, may be considered equivalent to the addition of a proportional quantity of oxygen to the atmosphere.

which he expresses in a more hypothetical manner, using a nomenclature which he had prematurely and unnecessarily adopted.

I cannot leave these essays without offering some further remarks on them. Many of the speculations in which they abound, it must be allowed, were wild and visionary; and yet the wildest of them are most natural to a young mind just entering on the twilight of physical science, gifted with high powers, and a vivid imagination; and I have no doubt that every young person similarly situated has experienced aspirations of the same kind. In the infancy of science itself, there were the same workings of the mind, the same yearning after unattainable knowledge and power: astrology was the result of it in the contemplation of the heavenly bodies; alchemy was derived from it in the laboratory; and magic from the study of natural science generally. Moreover, the period of his youth was one of peculiar excitement and innovation: the leaven of the French revolution was still fermenting; the mysterious phenomena of galvanism had recently been brought to light; the muscles of animals, apparently dead, had been made to contract by the new influence, as if reanimated; and pneumatic chemistry had just then been called to the aid of medicine, with a confident expectation of wonderful effects, which deluded men of the soundest minds, and which could be corrected only by experience. It is not remarkable, then, making allowance for these circumstances, that he thus indulged in speculation; but it is very remarkable how soon he liberated himself from the enchanting thraldom which has bound many for life, and how ever afterwards, intent on truth alone, he directed

his course through the boundless regions of science, which he explored free from the influence of all delusion. He writes of himself, —

"I began the pursuit of chemistry by speculations and theories: more mature reflection convinced me of my errors, of the limitation of our powers, the danger of false generalisations, and of the difficulty of forming true ones." This I find written in darker ink, between the lines of a note-book kept in 1799, consisting chiefly of speculative views concerning the connection of life and chemical action, or of physiology and chemistry. In after-life, and, indeed, very soon after the publication of these essays, he was severe, and, it appears to me, even in an undue degree, in censuring their faults. Dr. Hope has told me that, in one of the first conversations which they had together at Clifton, he expressed himself very strongly on this subject, and declared that he would joyfully relinquish any little glory or reputation which he might have acquired by his later researches, were it possible to withdraw these essays, and remove the impression which he *fancied then* they were likely to produce. This condemnation of them by himself was very characteristic of a sensitive and ingenuous mind, which is always most severe on its own faults, and is often more benefited by reflecting on them, than even by contemplating the most brilliant examples of excellence in others.

With all their faults of hasty speculation, of partial reasoning, and, in very many instances, erroneous experiments, I cannot help thinking that posterity will pass on these essays a sentence different from that of their author, and would, on no account, have them blotted out from the records of science;

this is the true test of their value, and of their deserving, not the unqualified censure which some critics have bestowed on them, but the qualified praise which they who know how difficult is the investigation and discovery of truth, and the navigation of the ocean of science, will most willingly give. I perceive that Dr. Paris, in his work, is not one of the last class of critics alluded to. After adopting one of my brother's views relating to the use of respiration, and calling it his own, as already mentioned, he breaks out in no measured terms of disapprobation, and says, that "the theory of phosoxygen and luminated phosoxygen has scarcely a parallel in extravagance and absurdity:" such terms do not appear to me to be at all applicable to the theory in question. The hypothesis was bold, but not absurd: it might be true, and we do not know but parts of it are true.

The chief fault of these essays is the hastiness of the generalisation, and the apparent presumption indicated by it; and this it was, I believe, that the author had most pain in reflecting on. He soon found out how vain is mere speculation, and that truth can only be attained by patient and laborious investigation; in brief, he soon became in the strictest sense, an inductive philosopher. Indeed, I am disposed to think that, in consequence of the publication of these essays, he almost immediately acquired, and for a short time felt, even an undue aversion to hypothesis. Bearing the date of August of the same year in which the essays appeared, there is the following reflection in his note-book:—"When I consider the variety of theories that may be formed on the slender foundation of one or two facts, I am con-

vinced that it is the business of the true philosopher to avoid them altogether. It is more laborious to accumulate facts than to reason concerning them; but one good experiment is of more value than the ingenuity of a brain like Newton's." In the same note-book, and written about the same time as the preceding, alluding to his essays, he says, "I was perhaps wrong in publishing, with such haste, a new theory of chemistry. My mind was ardent and enthusiastic. I believed that I had discovered the truth. Since that time, my knowledge of facts is increased, —since that time I have become more sceptical." He had then made some progress in experimental research, and viewed the vast regions which opened before him through an atmosphere less obscured by mist. In the same note-book he writes, "The man who would pretend, in the present state of our knowledge, to give a complete arrangement of facts, would pretend to an impossibility. Experimental science has but just commenced her existence." And again in October of the same year,—"Convinced as I am that chemical science is in its infancy, that an infinite variety of new facts must be accumulated before our powers of reasoning will be sufficiently extensive, I renounce my own particular theory as being a complete arrangement of facts; it appears to me now only as the most *probable* arrangement."

These private notes, never intended to meet the public eye, are valuable, as expressing his undisguised and genuine sentiments at this time. In a letter written to Mr. Nicholson in 1800, alluding to his theory, after stating some facts which he considers in favour of it, he adds, "but others have occurred to me, viz. the decomposition of bodies supposed

to contain light without any luminous appearance, which have made me a sceptic, with regard to my own particular theory, and theories of light in general."

Inquirers into physical science, especially those who are entering upon the pursuit, will do well to consider the errors which he fell into in these essays, the manner in which he renounced and corrected them, and the heightened ardour with which he prosecuted his search after truth.

The first great fault committed was the believing an experiment correct which was incorrect (imagining the abraded particles of iron fused when they were not, deceived by a microscopic appearance): I allude to the first experiment detailed in his essays, and founding on that a theory.

It is interesting to see in his note-books how he labours at the subject, endeavouring to investigate it more fully, and make amends for his early precipitancy. Though he was not aware of it when he published his essays, the same experiment had been made long before by Mr. Hawkesbee, and with a somewhat different result. This induced him to repeat it very carefully; and though he could obtain no sparks on the collision of steel and flint in a vacuum, there was a faint light produced, as stated by Mr. Hawkesbee. He next endeavoured to discover the cause of this light. He found it was only produced when a very thin flint was used, the edge of which was shattered, and that it was not connected with abrasion, and fusion of any particles of iron. Proceeding a step further, he ascertained that flint, like glass, becomes electrical by friction; and he concluded, therefore, that the light observed in vacuum on its "collision, was probably an elec-

trical phenomenon, produced by the accumulation of electrical fluid between the striking surfaces, and its rapid transmission to a conducting body." Finally, he made another experiment, which he considered as decisive. He substituted a piece of hard iron pyrites for flint in the gun-lock, a substance neither electrically luminous, nor phosphorescent from heat or friction. It gave very brilliant and copious sparks, when snapped in the air, from the combustion of particles of iron abraded, and of the pyrites; but snapped in vacuum in the dark, it gave no light, however feeble. "From this we learn," he says, "that the temperature produced by collision is not sufficient to occasion the ignition of the metallic particles, though it is adequate to their combustion. Mr. Stoddart has shown that iron begins to change colour at 432° Fahrenheit; and though the thinnest iron wire will not continue to burn till it has been very intensely heated, yet there is every reason to suppose that, in the smallest isolated particles struck off from the steel, the heat produced by the first degree of oxydation may be sufficient to carry on the process." *

The next subject of chemical inquiry that attracted his attention, of which I find any record, was of a very different nature from the preceding, arising from the observation of a child, and carried on experimentally, step by step, till it brought him to an interesting and important conclusion, in regard to the economy of nature in the vegetable kingdom. The results he obtained, he communicated to Mr. Nicholson, and they were published in his Journal.†

* MS. Vide Nicholson's Journal, 4to, vol. i. p. 516., and vol. iii. 8vo, p. 104.

† Nicholson's Journal, 4to. vol. iii. p. 56.

I shall transcribe the greater part of the paper, as the Journal is now rare, and the investigation is a happy and simple instance of chemical research, guided and extended by analogy, in which a single chance observation is the germ of an interesting and instructive series of experiments, showing how the material of the hardest rocks exists in, and constitutes the shell and armour as it were of the most delicate plants, and imparts adequate strength, without impairing either their flexibility or lightness: —

"Experiments and observations on the silex composing the epidermis, &c.

"1. A few days ago, Mr. Coates, of Clifton, informed me that his son, accidentally rubbing two pieces of bonnet-cane together in the dark, had perceived a luminous appearance. This phenomenon was sufficiently novel and curious to induce me to examine it. I found that all canes of this kind, when briskly rubbed together, produced sparks of white light. The luminous appearance was much more vivid on collision. When the canes were violently struck together, sparks, nearly as vivid as those from the gun-lock, were produced: at the same time a strong smell, similar to that generated by the collision of flint, or the excitement of the electric fluid, was perceived.

"2. I first thought that the phenomenon was electric, and depended on some resinous matter in the cane: the electrometer, however, was not sensibly affected during the experiment. When the cane was struck against wood of any kind, no light was perceived. When a cane was struck violently against quartz, agate, or any silicious stone, the light was as brilliant as when two canes were struck together.

The luminous appearance was produced when sharp steel was struck against the cane. When the cane was struck against sulphate of strontian, or barytes, or carbonate of lime, no light appeared.

"3. These circumstances induced me to suppose that the phenomenon depended on silicious earth in the epidermis, or in the whole of the cane. To determine this, I took off a small quantity of epidermis from one of the canes. It was hard, white, and had something the appearance of pulverised glass. When the epidermis was removed, the canes no longer possessed the property of giving out light on collision.

"4. To ascertain with certainty the nature of the epidermis, I obtained from 280 grains of cane twenty-two grains of epidermis: this was exposed in a crucible, to the strong heat of an air-furnace, for half an hour. It had lost three grains, was very white, infusible by the heat of the blow-pipe, and insoluble in any of the mineral acids. Ten grains of it were kept in fusion with caustic potash, in a silver crucible, for a quarter of an hour. The compound was white, and semi-pellucid. It was perfectly soluble in water, without communicating to it any turbidity. When muriatic acid was poured into the aqueous solution, a copious white flocculent precipitate was produced. This precipitate, collected, weighed about nine grains, and had every property of silex.

"5. To determine whether the wood and internal bark of the cane contained any silex, I burnt 240 grains, carefully deprived of the epidermis, for an hour. The ashes were perfectly white, and weighed about seven grains. When muriatic acid was poured upon them, a portion was dissolved with effervescence. This portion was chiefly carbonate of pot-

ash: the insoluble part collected weighed about two grains, and was apparently silex.

"6. Having ascertained, by these experiments, that the epidermis of the bonnet-cane was chiefly composed of flint, and that the luminous appearance above mentioned depended on this composition, I thought it probable that the other canes, particularly the sugar-cane, *arundo saccharifera*, and the bamboo, or *arundo indica*, were similar in their organisation. When two bamboos were struck together, I could perceive no luminous appearance. Four ounces of this cane only afforded seven grains of true epidermis. This, exposed to a strong heat, left five grains of white matter, which had all the properties of flint. The reason why these canes produce no light on collision, is, that the flint of the epidermis is too small in quantity, and too thinly diffused. The epidermis of the sugar-cane contained a still smaller proportion of flint: 200 grains of this gave five grains of white ashes, of which only one grain was insoluble in muriatic acid: the four grains of soluble matter appeared to be carbonate of lime. A large piece of bamboo (the weight of which I am ignorant of), deprived of the epidermis, gave a considerable quantity of white ashes, of which about two thirds were soluble in the muriatic acid: the insoluble part was silex. The ashes of the sugar-cane, deprived of the epidermis, appeared to be chiefly composed of carbonate of lime and carbonate of potash.

"7. The analogy between the English reeds and grasses, and the canes, and particularly the similarity of the appearance of the epidermis, induced me to suppose that they might likewise contain silex. On this supposition, I first examined the *arundo phragmites*, or

common reed. It produced no luminous appearance on collision with flint. Twenty-seven grains of the epidermis, exposed to a strong heat, gave thirteen grains of white earthy matter, insoluble in the mineral acids. Ten grains of this was fused with thirty-four grains of potash: the compound was soluble in water. The nitrous phosacid threw down from the aqueous solution a white flocculent matter, which was necessarily flint: this matter I did not weigh, but I conjecture that it was about seven or eight grains. One hundred and ten grains of the reed from whence the epidermis was removed gave about six grains of flint.

"8. I now examined the culm of wheat: 200 grains burnt gave thirty-one grains of white ashes; of these eighteen grains were soluble with effervescence in the muriatic acid: the remainder had all the properties of silex. The matter dissolved in the muriatic acid was potash. The ashes of oats and barley afforded silex in nearly the same quantities as those of wheat. The culms of the grasses, among which I examined *anthroxanthum*, *poa pratensis*, and some others, appeared to contain more silex in the epidermis than even the corns, with a much larger proportion of carbonate of potash.

"9. The silex in all these vegetables, as in the canes, appeared to be contained in the epidermis, or in the second bark. When the plants are carefully burnt, the figure of the epidermis is preserved. In the cane, when well burnt, it has a white glossy appearance, and is semi-transparent. In the reeds, corns, and grasses it is white and opaque, and, when viewed through a magnifier, appears to consist of longitudinal threads joined together by net-work: in the microscope, even the smallest particles have a distinct reticular appearance.

" 10. The quantity of carbonate of potash in the ashes of the corns and grasses induced me to suppose that, in a strong heat, they might be fused into glass. The ashes of the *arundo phragmites* were exposed to the strongest heat of an air-furnace for some minutes: there was no appearance of fusion, the carbonate of potash was not sufficient to form glass with the silicious earth. The ashes of straw, in a strong heat, gave a fine white transparent glass, perfectly insoluble in water, and indecomposable by acids. The ashes of hay gave a black glass, with a superabundance of potash. This conversion of corn and grass into glass may be effected by the blow-pipe, and affords a pleasing experiment. A straw, burnt with the blow-pipe, and urged with the strong heat of the blue flame, beginning at the top, is converted into a fine pellucid globule of glass, almost fit for microscopic experiments. A culm of grass is fused under the blow-pipe into a globule of glass, black and opaque, probably from its containing iron.

" 11. These facts will afford some curious inferences to the speculator in organised nature. The flint entering into the composition of these hollow vegetables, may be considered as analogous to the bones of animals: it gives to them stability and form, and, by being situated in the epidermis, more effectually preserves their vessels from external injury."

No one ever engaged in pursuit with loftier views before him, or with more sanguine expectations of attaining them. The former is strongly indicated by a passage in a note-book, which was written in the winter or early spring of 1799. He remarks, " The brilliant discoveries which have enriched chemical

science in these latter days, have, perhaps, induced the philosophers who made them to conclude too hastily that science had arrived at perfection. But though chemical theory has made some advance, when we consider our inability to calculate results; our ignorance of the attraction that binds many principles together, and of the composition of organic matter, we shall find that the field of nature is yet but little explored, and that the most sublime and important part of chemistry is yet unknown."—"In doctrine," he continues, "the attention has hitherto been confined to single and double affinities: even the union between the acids and alkalies, and metallic oxides, has been considered as effected by the simple attractions of the individual compounds; nothing has been done towards estimating the attractions of the simple principles in compound substances. The perfection of chemical philosophy, or the laws of corpuscular motion, must depend on the knowledge of all the simple substances, their mutual attractions, and the ratio in which these attractions increase or diminish, with increase or diminution of temperature. These being ascertained, chemistry would become a science so far generalised as to enable calculations to be formed with regard to the result of any new apposition of particles. The first step towards these laws will be the decomposition of those bodies which are at present undecompounded." The bodies thus alluded to were the fluoric, muriatic, and boracic acids, the alkalies, and earths; the elements of all which, in a few years from this time, he succeeded in developing: even now he attempted it in regard to the acids, as some further extracts will show. I shall give them in the order in which they occur:

they are well fitted to display the vastness of the scheme of research which he then proposed to enter upon. The following "Prospectus of Experiments" was written in the spring of 1799: —

"To decompose the muriatic, boracic, and fluoric acids; to try triple affinities, and the contact with heated combustible bodies at a high temperature."

"To ascertain all the phenomena of oxydation."

"To discover with accuracy the vegetable process."

Immediately after he notices other great undertakings which he contemplated: —

"Two great works, —

"'The Laws of Corpuscular Motion.'

"'The Theory of Passion.'

"Smaller ones, —

"'The Theory of Light, founded upon Experiments.'

"'An Account of Experiments.'"

In the following page he asks, "May we not be able to decompose muriatic acid by heating some of the muriates of the metals red, and sending sulphur in vapour through them? The muriate of lead might be tried in this way, or the muriate of copper. The attraction of copper for sulphur, and the attraction of sulphur for oxygen, would most probably effect the decomposition." From which it is evident that, in conformity with the then received analogies, he supposed muriatic acid a compound of a base and of oxygen.

He proposes other methods to endeavour to effect the decomposition; but I can find no precise mention of the results, excepting of an experiment on electrifying, or passing sparks through muriatic acid gas, which underwent no change: there are, in-

deed, slight notices of experiments, which failed, just sufficient to bring them to his recollection; they were all unsuccessful, and did not require to be minutely recorded. He must have satisfied himself by his first trials, that his means at that time were not adequate to the end; and he does not appear to have renewed the attempt till his extended researches had made him master of a new agent of analysis, whose power did not disappoint him. Fortunately, instead of wasting his time in ineffectual efforts to obtain the elements of the undecomposed acids and alkalies, he now engaged in other inquiries, of a more practicable nature, and in accordance with the views for which the Pneumatic Institution was founded.

In the beginning of 1799, he took up his residence in a house in Dowery Square, Clifton, which was fitted up for the purposes of the institution, and provided with a laboratory, &c. Here he applied himself with the greatest assiduity and zeal to the investigation of the effects of gases in respiration. One of the gases which he first experimented upon was nitrous oxide. Its agency was of a very novel and wonderful kind, contrary to all expectation, and almost exceeding belief. This discovery gave a particular direction to his inquiries, and may be considered as the origin of that work which contained the results of these inquiries, and which established his character as a chemical philosopher. It was published in 1800, in one volume 8vo, with the unassuming title of "Researches, Chemical and Philosophical, chiefly concerning Nitrous Oxide and its Respiration."

This work is deserving of the attention of the philosophical chemist, both as regards its author, and

the history of chemical science. In the latter, it will ever be memorable; and, had he never written any other work, I cannot help thinking that it would have immortalised his name. The order which he observed in the arrangement of his materials was not adapted to allure the ordinary reader. It was altogether scientific, and designed for the man of science, as, indeed, was the work in its design throughout; and, in consequence, though it was immediately on its publication received with avidity by those to whom it was addressed, and eulogised in a very high degree, and constantly referred to by systematic writers on chemistry, yet the sale of it was not extensive, and a second edition of it was never required; a proof, I may remark in passing, how few in number are the original inquirers in the multitude of those who pretend to the name of chemical philosophers in Britain.

The chemical reader I must refer to the work itself: it is only by carefully studying it that a just idea can be formed of the important additions which the author made to the stock of chemical knowledge, the manner in which he conducted his experimental researches at this time, and the severe logic which he employed in reasoning on the results he obtained. In this place, a very concise notice of the greater part of it must suffice. It was composed of four parts, or researches. The first research was chiefly on the production or mode of obtaining nitrous oxide, and on the analysis and composition of nitrous gas and nitrous acid. The second research was on the composition of nitrous oxide; its decomposition by combustible bodies; and the combinations it was capable of forming. These parts were purely chemical,

and displayed his invention and skill equally in contriving and executing experiments to solve problems which were then obscure, relative to the combinations of azote with oxygen, though they had previously attracted the attention of, and had been investigated by, some of the most distinguished chemical philosophers. The other two parts were of a different nature, and were chiefly physiological and medical. The third research was on the action of nitrous gas on animals, and on the changes effected in it by respiration; and the fourth, and last, was on the effects of breathing this and other gases, giving the history of a series of experiments made on himself, perhaps the boldest ever undertaken by man, the majority attended with risk, and some of them with the most imminent danger to life. This research is the most original portion of the whole work, and the most generally interesting; and is very characteristic of him, especially at this period of his life, when an ardent enthusiasm was kindled in his mind, and he was equally excited by the love of knowledge and glory into the course of scientific discovery, which he then commenced.

He thus enters upon the subject: —

"A short time after I began the study of chemistry, in March, 1798, my attention was directed to the dephlogisticated nitrous gas of Priestley, by Dr. Mitchell's Theory of Contagion;" and he adds in a note, "Dr. Mitchell attempted to prove, from some phenomena connected with contagious diseases, that dephlogisticated nitrous gas, which he called oxide of septon, was the principle of contagion when respired by animals in the minutest quantities, or even when applied to the skin or muscular fibre."

He continues, "The fallacy of this theory was soon demonstrated by a few coarse experiments made on small quantities of the gas procured from zinc, and diluted nitrous acid. Wounds were exposed to its action; the bodies of animals were immersed in it without injury, and I breathed it, mingled in small quantities in common air, without remarkable effects. An inability to procure it in sufficient quantities, prevented me at the time from pursuing the experiments to any greater extent. I communicated an account of them to Dr. Beddoes."

After describing some experiments on breathing it in a diluted state, in which it appeared to render the pulse slower, he proceeds to notice his determination to inhale it pure, giving his reasons for so doing. He says, —

"In April I obtained nitrous oxide in a state of purity, and ascertained many of its chemical properties. Reflections upon these properties, and upon the former trials, made me resolve to endeavour to inspire it in its pure form; for I saw no other way in which its respirability or powers could be determined.

"I was aware of the danger of this experiment: it certainly never would have been made if the hypothesis of Dr. Mitchell had in the least influenced my mind. I thought that the effects might be possibly depressing or painful; but there were many reasons which induced me to believe that a single inspiration of gas, apparently possessing no immediate action on the irritable fibre, could neither destroy, nor materially injure, the powers of life." This resolution he carried into effect on the 11th of April, and again on the 16th and 17th; when he

experienced for the first time the remarkable intoxicating operation of the gas. The following is his account of the experiment, and of the sensations which he perceived:—

"Having previously closed my nostrils, and exhausted my lungs, I breathed," he says, "four quarts of the nitrous oxide from and into a silk bag. The first feelings were similar to those produced in the last experiment (viz., a sense of fulness of the head; loss of voluntary power, &c.); but in less than half a minute, the respiration being continued, they diminished gradually, and were succeeded by a sensation analogous to gentle pressure on all the muscles, attended by a highly pleasurable thrilling, particularly in the chest and extremities. The objects around me became dazzling, and my hearing more acute. Towards the last inspirations, the thrilling increased; the sense of muscular power became greater; and at last an irresistible propensity to action was indulged in. I recollect but indistinctly what followed. I know that my motions were various and violent. These effects very soon ceased after respiration: in ten minutes I had recovered my natural state of mind. The thrilling in the extremities continued longer than the other sensations. This experiment was made in the morning: no languor nor exhaustion was consequent; my feelings throughout the day were as usual; and I passed the night in undisturbed repose. The next morning the recollections of the effects of the gas were very indistinct; and had not remarks, written immediately after the experiments, recalled them to my mind, I should have even doubted of their reality. I was willing, indeed, to attribute some of the strong emo-

tion to the enthusiasm which I had supposed must have been necessarily connected with the perception of agreeable feelings, when I was prepared to experience painful sensations. Two experiments, however, made in the course of this day with scepticism, convinced me that the effects were solely owing to the specific operation of the gas."

I must refer the curious reader to the work itself, for the minute details of the experiments made under a variety of circumstances on the inspiration of nitrous oxide, with an intrepidity and resolution almost without parallel in the history of scientific research. The most striking effects of the gas were produced in the bold experiment of including himself in an atmosphere in part composed of it, and breathing it for a considerable time, and afterwards inhaling it pure. I shall extract the latter part of the account which he has given of the trial; it has a dramatic and almost poetical interest, and, indeed, I believe that the following poetical effusion was founded on it: —

"Not in the ideal dreams of wild desire
Have I beheld a rapture-wakening form:
My bosom burns with no unhallow'd fire,
Yet is my cheek with rosy blushes warm;
Yet are my eyes with sparkling lustre fill'd;
Yet is my mouth replete with murmuring sound;
Yet are my limbs with inward transports fill'd,
And clad with new-born mightiness around."

But to give the prose account, which is more poetical and exact: after breathing the nitrous oxide atmosphere for a considerable time, recording his sensations, and the effects on his pulse and temperature, he says, "I had now a great disposition to laugh; luminous points seemed frequently to pass before my

eyes; my hearing was certainly more acute; and I felt a pleasant lightness and power of exertion in my muscles. In a short time, the symptoms became stationary; breathing was rather oppressive; and, on account of the great desire of action, rest was painful. I now came out of the box, having been in precisely an hour and a quarter.

"The moment after, I began to respire twenty quarts of unmingled nitrous oxide: a thrilling, extending from the chest to the extremities was almost immediately produced. I felt a sense of tangible extension, highly pleasurable, in every limb; my visible impressions were dazzling, and apparently magnified; I heard distinctly every sound in the room, and was perfectly aware of my situation.* By degrees, as the pleasurable sensations increased, I lost all connection with external things; trains of vivid visible images rapidly passed through my mind, and were connected with words in such a manner as to produce perceptions perfectly novel. I existed in a world of newly-connected and newly-modified ideas; I theorised, I imagined that I made discoveries. When I was awakened from this semi-delirious trance by Dr. Kinglake, who took the bag from my mouth, indignation and pride were the first feelings produced by the sight of the persons about me. My emotions were enthusiastic and sublime, and for a minute I walked round the room, perfectly regardless of what was said to me. As I recovered my former state of mind, I felt an inclination to communicate the discoveries I had made during the experiment. I endeavoured to recall the ideas: they were feeble

* He adds, in a note, that, after the first minute in the experiments, his cheeks became purple.

and indistinct; one collection of terms, however, presented itself; and, with the most intense belief and prophetic manner, I exclaimed to Dr. Kinglake, '*Nothing exists but thoughts! the universe is composed of impressions, ideas, pleasures, and pains.*'

"About three minutes and a half only had elapsed during this experiment, though the time, as measured by the relative vividness of the recollected ideas, appeared to me much longer. Not more than half of the nitrous oxide was consumed: after a minute, before the thrilling of the extremities had disappeared, I breathed the remainder: similar sensations were again produced. I was quickly thrown into the pleasurable trance, and continued in it longer than before. For many minutes after the experiment I experienced the thrilling in the extremities. The exhilaration continued nearly two hours. For a much longer period I experienced the wild enjoyment before described, connected with indolence: no depression or feebleness followed. I ate my dinner with great appetite, and found myself lively and disposed to action immediately after. I passed the evening in executing experiments; at night I found myself unusually cheerful and active, and the hours between eleven and two were spent in copying the foregoing detail from the common-place book, and in arranging the experiments. In bed I enjoyed profound repose: when I awoke in the morning, it was with consciousness of pleasurable existence, and this consciousness, more or less, continued through the day."

What immediately follows is so very descriptive of the variable effects of the gas, that I am tempted to give it, especially as it contains some particulars re-

specting himself, incidentally introduced, of an interesting kind.

He continues: — "Since December I have very often breathed nitrous oxide. My susceptibility to its power is rather increased than diminished: I find six quarts a full dose, and I am rarely able to respire it in any quantity for more than two minutes and a half.

"The mode of its operation is somewhat altered: it is, indeed, very different at different times.

"I am scarcely ever excited into violent muscular action; the emotions are generally much less intense and sublime than in the former experiments, and not often connected with thrilling in the extremities.

"When troubled with indigestion, I have been two or three times unpleasantly affected with the excitement of the gas. Cardialgia, eructations, and unpleasant fulness of the head were produced.

"I have often felt very great pleasure when breathing it alone in darkness and silence, occupied only by ideal existence. In two or three instances, when I have breathed it amidst noise, the sense of hearing has been painfully affected, even by moderate intensity of sound. The light of the sun has sometimes been disagreeably dazzling. I have once or twice felt an uneasy sense of tension in the cheeks, and transient pains in the teeth. Whenever I have breathed the gas after excitement from moral or physical causes, the delight has been often intense and sublime.

"On May 5th, at night, after walking for an hour amidst the scenery of the Avon, at this period rendered exquisitely beautiful by bright moonshine, my mind being in a state of agreeable feeling, I respired six quarts of newly prepared nitrous oxide.

The thrilling was very rapidly produced. The objects around me were perfectly distinct, and the light of the candle not as usual dazzling. The pleasurable sensation was at first local, and perceived in the lips and about the cheeks; it gradually, however, diffused itself over the whole body, and in the middle of the experiment was for a moment so intense and pure, as to absorb existence — at this moment, and not before, I lost consciousness; it was, however, quickly restored, and I endeavoured to make a bystander acquainted with the pleasure I experienced, by laughing and stamping. I had no vivid ideas. The thrilling and pleasurable feeling continued for many minutes; I felt, two hours afterwards, a slight recurrence of these in the intermediate state between sleeping and waking; and I had, during the whole of the night, vivid and agreeable dreams. I awoke in the morning with the feeling of restless energy, which I had often experienced in the course of experiments in 1799."

Numerous trials of the gas by other persons, which are minutely described in his work, confirm these latter results relative to the variable nature of the effect of nitrous oxide. On some individuals, of little sensibility or irritability, it occasioned convulsive motions, and the breathing of it was not without danger. On no one, perhaps, was its pleasurable influence greater than on himself: he appears to have been of that temperament best adapted to be excited by it, and of a tone of mind best fitted to enjoy its excitements. If any one like his biographer, Dr. Paris, should consider the descriptions given in the "Researches" of the operation of nitrous oxide exaggerated, he would probably lose his scepticism,

had he read, as I have, the original minutes of the experiments, written immediately after the breathing of the gas, in which the novelty of feeling is strongly portrayed by several expressions which were omitted in publication, not because they were not true, but because they might seem to others extravagant. Thus, on one occasion, when under the delightful influence of the gas, he uses the expresion, "I seemed a new being;" on another, "I seemed a sublime being newly created;" on a third occasion, that he felt "as if possessed of new organs."

As a medicinal agent, he speaks of it with reserve. In proof of this, I cannot do better than transcribe the concluding paragraphs of the work, which are no less remarkable for rational scepticism, than for clearness of view and ardour of hope.

"As hydrocarbonate acts as a sedative, and diminishes living action as rapidly as nitrous oxide increases it, on the common theory of excitability*, it would follow, that, by differently modifying the atmosphere by means of this gas and nitrous oxide, we should be in possession of a regular series of exciting and depressing powers, applicable to every deviation of the constitution from health: but the common theory of excitability is most probably founded on a false generalisation. The modifications of diseased action may be infinite, and specific in different organs, and hence out of the power of agents operating on the whole of the system.

"Whenever we attempt to combine our scattered physiological facts, we are stopped by the want of numerous intermediate analogies, and so loosely connected, or so independent of each other, are the dif-

* That of Brown, modified by his disciples, which was then in fashion.

ferent series of phenomena, that we are rarely able to make probable conjectures, much less certain predictions, concerning the results of new experiments.

"An immense mass of pneumatological, chemical, and medical information must be collected before we shall be able to operate with certainty on the human constitution.

"Pneumatic chemistry, in its application to medicine, is an art in infancy, weak, almost useless, but apparently possessed of capabilities of improvement. To be rendered strong and mature, she must be nourished by facts, strengthened by exercise, and cautiously directed in the application of her powers by rational scepticism."

For the particulars of his very dangerous experiments on the breathing of carburetted hydrogen, carbonic acid gas, azote, hydrogen, and nitrous gas, in which more than once his life was nearly sacrificed, I must also refer the reader to the "Researches." Those persons who are disposed to censure him for the rashness of the undertaking, should remember it was done in the ardour of youth, and in the enthusiasm of scientific research, and after the discovery of the influence of nitrous oxide, as unexpected as it was extraordinary. One or two of his experiments he regretted having attempted, almost as soon as they were made, because they were instituted in the face of manifest danger, and without any reasonable prospect of a beneficial or even innocuous result; and he seems to have published them chiefly as a warning to others. A few years afterwards, his opinion of the impropriety of making on oneself experiments of danger, was very decided. It is contained in a letter to a young

friend, who was then studying medicine, and, with the same carelessness of life, was trying on himself the effects of narcotics. "I have heard," he says "of some experiments you have made on the action of digitalis, and other poisons, on yourself. I hope you will not indulge in trials of this kind. I cannot see any useful result that can arise from them. It is in states of disease, and not of health, that they are to be used; and you may injure your constitution without gaining any important result. Besides, if I were in your place, I should avoid being talked of for any thing extraordinary of this kind, as you have already fame of a better kind, and the power of gaining fame of the noblest kind."

He wrote thus, it may be supposed, with a distinct recollection of the danger he had escaped of the immediate loss of life in the experiments before alluded to, and of the injury his health then sustained, so as to oblige him to desist from his researches for a time, when he was most intent on them, and seek the renewal of health and strength in his native air.

This, his first visit home, in the latter part of October, 1799, was marked by the same ardour as he showed in every thing he undertook. He wrote to announce his intention, and arrived before his letter. He then remained at Penzance about a month, variously occupied, dividing his time between his family and his old friends, and his favourite amusements of fishing, shooting, geologising, and experimenting. Though his visit was for so short a time, and suddenly determined on, yet he brought with him a case of chemical apparatus, considerably larger than the one which some years after he carried

with him on his continental travels; and it may be still in existence, in the possession of a gentleman of the Mount's Bay, to whom he gave it when he was about to return to Bristol, in exchange for a present of Cornish minerals.

His feelings towards home, and the friends of his youth, were always warm and grateful, and they are strongly expressed in many of his early letters. I shall here insert two of these,—one to his mother, written soon after the visit just noticed, in reply to a letter from her of anxious inquiry, in consequence of a longer silence on his part than usual; and another to his first benefactor, Mr. John Tonkin:—

"Hot Wells, November 19. 1800.

"My dear Mother,

"Had I believed that my silence of six weeks would have given you a moment's uneasiness, I should indeed have written long ago. But I have been much engaged in my favourite pursuit of experimenting, and in endeavouring to amuse two of my friends who have spent some days at the Institute. One of them is your quondam lodger, Gregory Watt, who desired to be kindly remembered to you and the family. The other you have heard me speak of: his name is Thomson; and he is one of the few to whom God has given a spirit carrying them above the common things of the world.

"Accept my affectionate thanks for your presents. I have received them all, and I have made a good use of them all. Several times has a supper on the excellent marinaded pilchards made me recollect former times, when I sat opposite to you, my dear mother, in the little parlour, round the little table

eating of the same delicious food, and talking of future unknown things. Little did I then think of my present situation, or of the mode in which I am, and am to be, connected with the world. Little did I then think that I should ever be so long absent from the place of my birth as to feel longings so powerful as those I now feel for visiting it again.

"I shall see with heartfelt pleasure the time approaching when I shall again behold my first home—when I shall endeavour to repay some of the debts of gratitude I owe to you, to the Doctor, and to my aunts. My next visit shall not be so short a one as the last. I will stay with you at least two or three months. You have let half your house. Have you a bed-room reserved for me, and a little room for a laboratory? Which part have you let?

"When I come to Penzance we will settle all about John; till then I should like for him to learn French and Latin with Mr. Dugart. The expense of this or any other part of his education I will be glad to defray. Do not by any means put him with Mr. Coryton. I have long procured the paints: if there is no vessel in the course of a week, they shall be sent off by the waggon.

"I will write to Kitty in the course of next month. I am glad to hear Grace is better. Remember me with affection to her. I have not yet seen Mr. Griffin. Any one who has lately seen my friends I shall be glad to see.

"Have the goodness to tell Mr. Borlase that I will endeavour to procure the book he wished for in London.

"All in the way of progress goes on nobly. My health was never better than it has been since I left

Cornwall last. I shall be very glad to hear from you soon. You have a hundred objects to write about interesting to me. I can write only of myself. Remember me with affection to all my friends (particularly the Doctor), my aunts and uncles. Love to Kitty, Grace, Betsy, and John.

"Farewell, my dear mother.

"I am your affectionate son,

"H. Davy."

"Dowery Square, Clifton, January 12. 1801.

"Respected Sir,

"I have sent in the box enclosing this letter and a set of paints for John, two bottles, containing different preparations of phosphorus, with directions for using them. The mode of conveyance by the waggon is very slow; I shall not, therefore, attempt to fill my pages with any thing that may be called news. Never was the state of public affairs in England more confused than at this moment, and never were the hopes of peace and plenty* feebler in the public mind.

"The apathy connected with politics and morals does not, however, prevail with regard to the physical and medical sciences. Agriculture, the first of the arts, was never cultivated with greater ardour than at present. Natural philosophy has lately been enriched with many curious discoveries, amongst which galvanism, a phenomenon that promises to unfold to us some of the laws of our nature, is one of the most important. In medicine, the inoculation for the cow-pox is becoming general, not in England alone, but

* The reader will remember that this was a time of extraordinary dearth.

over the whole of Europe; and, taking circumstances as they now stand, it promises gradually to annihilate small-pox.

"My discoveries relating to the nitrous oxide, the pleasure-producing air, are beginning to make some noise: the experiments have been repeated, with the greatest success, by the professors of the University of Edinburgh, who have taken up the subject with great ardour; and I have received letters of thanks and of praises for my labours from some of the most respectable of the English philosophers. I am sorry to be so much of an egotist; yet I cannot speak of the Pneumatic Institution and its success without speaking of myself. Our patients are becoming daily more numerous, and our Institution, in spite of the political odium attached to its founder, is respected, even in the trading city of Bristol. I shall soon send you an account of the success we have had in curing some of the most obstinate diseases by new remedies. The nitrous oxide we have found very beneficial in many cases of palsy.

"I hope sincerely that you will pass over the winter without any return of your complaint. The weather was never milder in April than it is now at this place in January. The autumn and the spring seem to mingle together without being separated by a winter.

"I am at this moment very healthy and very happy; I have had great success in my experiments, and I gain a competence by my pursuits, at the same time that I am (in hopes at least) doing something towards promoting the public good. If I feel any anxiety, it is that of being removed so far from you, my mother, and my relations and friends. If I was

nearer, I would endeavour to be useful to you; I would endeavour to pay some of the debts of gratitude I owe to you, my first protector and earliest friend. As it is, I must look forward to a futurity that will enable me to do this: but, believe me, wherever I am, and whatever may be my situation, I shall never lose the remembrance of obligations conferred on me, or the sense of gratitude which ought to accompany them.

"I remain, respected Sir,
"With unfeigned duty and affection, yours,
"H. DAVY."

This letter was written in 1801; and it was the last, I believe, he ever addressed to his respected friend, who very soon after quitted life in advanced age (he was in his eighty-second year), regretted by his fellow-townsmen, amongst whom he held a distinguished place, looked up to for his sterling worth and strength of judgment, and more than usually lamented by a circle of friends, to whom he was very dear for his benevolence, kindness, and very generous and friendly disposition. He will long be remembered in Penzance, both for excellencies and peculiarities. The latter marked him as a person of the gone-by time, and attracted the notice even of the careless observer. He held in aversion modern changes of fashion, and in his old age wore the dress of his youth—the cocked hat, large powdered wig, hand-ruffles, upright collar; in brief, the professional dress of the beginning of the last century; and his manly form and countenance suited well with this venerable costume. Of a quick temper, and much indulged, he was angry with my brother for accepting the ap-

pointment at the Pneumatic Institution, and made some alteration, it is said, in his will in consequence. But his anger was of short duration; his kindest feelings soon returned, and he never ceased to be interested in his welfare, and to rejoice in his success.

In further confirmation of my brother's warm feelings towards the place of his birth, and his early friends, I shall give some verses, irregularly written, apparently in the enthusiasm of revisiting home, heightened by various emotions from acquired and anticipated fame in the pursuit of science: —

——— "Many days have pass'd,
Beloved scene, since last my wet eyes saw
The moon-beams gild thy whitely-foaming waves.
Ambitious then, confiding in her powers,
Spurning the prison, — onward flew my soul
To mingle with her kindred; — in the breeze
That wafts upon its wings futurity,
To hear the voice of praise; — and not in vain
Have these high hopes existed, — not in vain
The dew of labour has oppress'd my brow,
On which the rose of pleasure never glow'd;
For I have tasted of that sacred stream
Of science, whose delicious water flows
From Nature's bosom. I have felt the warmth,
The gentle influence of congenial souls,
Whose kindred hopes have cheer'd me; who have taught
My irritable spirit how to bear
Injustice; who have given
New plumes of rapture to my soaring wing
When ruffled with the sudden breath of storms.
Here, through the trembling moonshine of the grove,
My earliest lays were wafted by the breeze, —
And here my kindling spirit learn'd to trace
The mystic laws from whose high energy
The moving atoms, in eternal change,
Still rise to animation.
Beloved rocks! thou ocean white with mist,
Once more with joy I view thee;
Once more ye live upon my humid eyes;
Once more ye waken in my throbbing breast
The sympathies of nature. Now I go

Once more to visit my remember'd home,
With heartfelt rapture, — there to mingle tears
Of purest love, — to feel the ecstatic glow
Of warm affection, and again to view
The rosy light that shone upon my youth."

To recur to his "Researches," which were published in the middle of the summer of 1800: a work so laborious might have sufficed for the life of an ordinary man; the materials of it were collected and put together in an almost incredibly short time. In a note-book now before me, there is a rough draft of a preface, in which he says, "These experiments have been made since April, 1799, the period when I first breathed nitrous oxide. Ten months of incessant labour were employed in making them, three months in detailing them."* Most men, after such a labour, would have allowed themselves rest; but with him exertion was a pleasure, and one was only the prelude to another. In an unpublished dedication of his "Researches" to Dr. Beddoes, he begs him to receive them "as pledges of more important labours;" and even before they were given to the world, he had entered upon new inquiries — he had begun that series of galvanic experiments which ultimately led to some of his greatest discoveries. These I shall

* During the same period he made a large number of experiments on the salts of ammonia, especially its carbonates, the details of which he never published, the inquiry having been left unfinished. He ascertained many facts respecting them at that time new: he found that the sesquicarbonate of ammonia is partially decomposed by heat; that a portion of carbonic acid is expelled in the gaseous form; and that a salt sublimes saturated with the volatile alkali, very acrid and deliquescent. He considered it a new compound. From a recent examination, I have satisfied myself that it is a hydrate composed of one proportion of ammonia, of one of carbonic acid, and of one of water, which hitherto has been overlooked by chemists. — *Vide The Edinburgh New Philosophical Journal for April,* 1834.

consider further on. There were other pursuits which had a portion of his time at Bristol, which require some attention in exemplification of the varied powers of his mind, and that at a time when he was most intensely occupied in experimental research.

The following memorandum, which occurs in a note-book kept when he first went to Bristol, will give the reader a distinct idea of the intellectual life he then led, and of that variety of pursuit just alluded to:—

"*Resolution.*—To work two hours with pen before breakfast on the 'Lover of Nature;' and 'The Feelings of Eldon,' from six till eight; from nine till two, in experiments; from four to six, reading; seven till ten metaphysical reading (i. e. system of the universe)."

And his note-books generally, at this period, were not less characteristic; they contain mixed together, without the least regard to order, schemes and minutes of experiments, passing thoughts of various kinds, lines of poetry (but these are in small proportion), fragments of stories and romances, metaphysical fragments, and sketches of philosophical essays. Some specimens may not be uninteresting.

Amongst the last-mentioned, the essays, there is one on Education, one on Luxury, one on Genius, and one on Dreaming. That on education is called "Hints towards a Treatise to be entitled Observations on Education and the Formation of the Human Intellect, designed for the Use of Parents and Instructors." In the beginning of it he adverts to the impulses to which the fœtus *in utero* is exposed, according to a very early speculation already mentioned. He supposes that the feelings which may

be there experienced by means of the sense of touch and of hearing "may have an influence on the individual, in the same manner as the feelings of the first two or three years of childhood, though not recollected, may have on the character of the man." He next considers how the child may be affected after birth; what are the sources of its pleasures and pains; and how the passions result from them. He insists on the propriety of not associating pain with moral agents, and of giving infants as little pain as possible, soothing them when cross, and not beating them, so that the irascible passions may be kept down, and not excited. On the same humane principle, when children are ill, he inculcates the opposing irritable and peevish feeling by all innocent means adapted to amuse and please them, so that their attention may be diverted from pain. He hints at the punishment of children, when necessary, by machines, that the pain inflicted may not be associated with a moral agent. He alludes to the "detestable practice of humouring children by turns." He proposes showing them the beauties of nature. He notices "the miserable habit of punishing them by anticipated pain, by which that pain becomes associated with ideas which have no relation to the fault." These are some of the heads of the treatise belonging to the first era; others of a second and third era are also given, but without any details. It is probable that he never went further with this intended treatise; yet here and there notices are dispersed, as if in the way of preparation for it, and indicating that the subject was still floating in his mind. There occurs in one of his note-books the opening of a romance, "The History of Passion; a

Philosophical Narrative," which was perhaps intended to embody his ideas on the subject of education, and the developement of the human character; and it is preceded by the following sketch of man in his progress through life: —

"The Infant, being of sensation.
"The Youth, being of imagination.
"The Lover.
"The Social being.
"The Logopathist.
"The Lover of money.
"The Lover of science.
"The Lover of nature.
"Recurrence of former feelings.
"The Lover of future existence."

Hereafter I shall insert a poem of his, which was written, in part, in 1801, and which bears the stamp of the same train of thought; as, indeed, did his own life generally, as if he wrote from his perceptions of self more than from reflections on others.

Of the "Essay on Genius," fragments merely were written. He commences with noticing "The wonderful difference in the nature of men, between those who are insignificant in their powers, and apparently isolated in their influences—who live only whilst they move, and cease to act as soon as they cease to exist; and those whose agency extends over the whole social world—who are full of energy in life, and leave behind them monuments of thought capable of perpetuating their existence." He inquires, "What is this generating faculty of man, which acts through the immensity of ages? How is it produced, and in what manner does it operate?"

"Great powers," he observes, "have never been

exerted independent of strong feelings. The rapid arrangements of ideas, from their various analogies to the equally rapid comparisons of these analogies, with facts uniformly occurring during the progress of discovery, have existed only in those minds where the agency of strong and various motives is perceived — of motives modifying each other, mingling with each other, and producing that fever of emotion, which is the joy of existence, and the consciousness of life."

The heads (for there is little more) of his "Observations on Luxury" express clearly his opinions on this subject, and they are not unworthy of maturer years; nor do I believe that he ever swerved from the principles contained in them, though, at times, some of his habits of life might appear to be, as they were said to be, luxurious. I shall make only one extract from them: —

"Nature and domestic attachments the true sources of happiness. Cosmopolitanism, the love of notoriety, not fame, — the love of pleasure, all fatal to the first and strongest feelings of our nature. In general society, the feelings are so mixed up, and prevented from ever arriving at maturity; hence the *petit maître-ism* of men and women of quality."

On the subject of dreams a good many observations occur, and many of them arising out of his own experience. His theory of them is expressed in the following passage: —

"Our waking existence is composed of impressions, ideas, and feelings, of different degrees of vividness, which succeed each other in what may be called trains. The past is simple memory, the future is analogy, and the present is made up of impressions, sometimes, though rarely, simple, but often mixed or

associated with the past and the future. In dreams, all the ideas occurring seem to be of one degree of vividness. There is neither past nor future, no mixture of impressions with ideas; the feelings occur as in waking, though seldom connected with what may be called the secondary reflective feelings, those produced when an action, at first pleasant, after a time becomes the contrary. The mixtures of memories and analogies, which are mingled, in waking, by the peculiarly modifying and connecting impressions in the order of nature, are here called up and modified only by slight organic feelings; generally so slight as to lose their independent existence, and can only be traced by impressions which are connected with them."

The works of fiction, to which, it has been remarked, he even now occasionally turned his attention, from the fragments of them which remain, appear to have been intended to illustrate, in a popular manner, his own philosophical and metaphysical views; such as "The Child of Education, or the Narrative of W. Morley;" "The Lover of Nature, or the Feelings of Eldon;" "The Dreams of a Solitary;" "Imla, the Man of Simplicity; a Romance;" "The Villager; a Tale for the common People, to prove that great Cities are the Abodes of Vice," &c. Of some of these only the titles and plans are given; of others, portions are written; but they are so intermixed with notices on other subjects, and reflections, that it is often difficult to distinguish between what is noted down as his own sentiments and feelings, and what is sketched as the sentiments and feelings of the imaginary persons of his stories. In this respect there is a considerable resemblance

between these fragments and the last works which he composed; viz. "Days of Fly-fishing," and "The Last Days of a Philosopher," or "Consolations in Travel;" and it is curious to see that between them there are other and more important points of resemblance; as if in his latter days, when he was no longer able in sickness to apply himself to the laborious researches of science, there was a renewal of his former ideas, a revival of former intentions, and with them of early trains of thought and feeling. I shall give some extracts, partly with a view of showing this; and, first, a sketch of a reverie, not unlike part of that which is described in the "Consolations in Travel" to have occurred in the Colosseum.

"I awoke at midnight: the recollection of indistinct but painful visions passed across my mind; the spectre of horrible images still trembled in my eyes when I raised them to the light which shone through the green windows of my chamber. The moon was high in heaven; the sky was blue and cloudless; the woodbine, that surrounded the casement, was waving its dark foliage to the breeze. How intimately connected together are life, light, and motion! I was no longer solitary, no longer terrified; the restless and uneasy feeling which superstition, almost conquered by reason, is capable of awakening in the mind, disappeared before the beautiful, or combined with it to form sublime energy. You know a moonlight scene is peculiarly delightful to me; I always considered it as beautiful: but so much solitary enthusiasm, so much social feeling, so much of the sublime energy of love, of sorrow, and consolation, have occurred to me beneath the moonbeams, on the shore of that sea where Nature first spoke to me in the murmurs of

the waves and winds, in the granite caves of Michael, that it is now become sublime. Restless, and filled with vivid imaginations, I was unable to sleep: I arose and stole to the window. The moon had just sunk beneath the ruins of the abbey, and her broken and trembling light shone through the west windows upon the burying-ground; beyond which the moving waters of the Wye were dancing and murmuring beneath the light. For a few minutes I was lost, and swallowed up in impression. No longer connected with the earth, I seemed to mingle with Nature; I pursued the dazzling of the moonbeams; I raised myself above the stars, and gave imaginary beings to the immeasurable paths of ether. But when I cast my eyes on the remains of mortality, — when I considered, that in that deserted spot, where the song of the nightingale and the whispering of the wings of the bat were the only signs of life, thousands of thoughts, an immense mass of pleasurable ideas, had rolled through the minds of a hundred intelligent beings,—I was lost in a deep and intense social feeling. I began to think, to reason, What is existence? what is this eternal series of changes in life, in thought, and sentiment? The globe undergoes no physical revolution, whilst the physical organised beings upon the surface of it are perpetually modifying; the laws by which the physical phenomena of the universe are ruled are always the same: are there no laws by which the moral phenomena are governed? Nothing remains of them but mouldering bones; their thoughts and their names have perished. Shall we, too, sink in the dust? shall we, too, like these beings, in the course of time, be no more? shall that ever-modified consciousness be lost in the immensity of being? No,

my friend, individuality can never cease to exist; that ideal self which exists in dreams and reveries, that ideal self which never slumbers, is the child of immortality, and those deep intense feelings, which man sometimes perceives in the bosom of Nature and Deity, are presentiments of a more sublime and energetic state of existence."

The following passage, strongly expressive of sympathy with nature, reminds me of the vivid and beautiful description in the "Consolations in Travel," at the opening of the third dialogue, in approaching Pæstum:—

"To-day, for the first time in my life, I have had a distinct sympathy with nature. I was lying on the top of a rock to leeward; the wind was high, and everything in motion; the branches of an oak tree were waving and murmuring to the breeze; yellow clouds, deepened by grey at the base, were rapidly floating over the western hills; the whole sky was in motion; the yellow stream below was agitated by the breeze; everything was alive, and myself part of the series of visible impressions; I should have felt pain in tearing a leaf from one of the trees." There is a break in the writing, and a metaphysical remark follows:—"Deeply and intimately connected are all our ideas of motion and life, and this, probably, from very early association. How different is the idea of life in a physiologist and a poet!"

The following passage was almost prophetically true of himself, descriptive of the feelings of a philosopher in his last hours; such as he imagined them in youth, such as he found them thirty years after, when I joined him at Rome, in his last illness:—

"Behold me on the couch of death, my senses lost,

my organs falling towards that state in which they will resolve into their primitive atoms: still is my mind unconquered, still all my passions, all my energies, are alive; still are all my trains of thinking complete. Philosophy has warmed me through life: on the bed of death she does not desert her disciple. The frost of the grave can never chill those burning energies connected with the thoughts of future existence. I feel and believe that the genial warmth of the sun of immortality, which has shone through this shattered frame with feeble light, shall be more permanent in the regions of bliss. I feel within me new energies; these hopes do not announce pain or annihilation. Oh, happy man! oh, benevolent Deity! thou art every where existing; and where thy permanent essence is interfused, pain cannot be permanent. Then the vain philosophy of the schools, the dull and dry heaps of words which have been called metaphysics, crossed my mind; but their influence was lost, and swallowed up in the genial illumination, as the noise of the mountain torrent amidst the majesty of visible imagery is lost and disregarded."

The next extract carries me back to his early youth; and the manner, as related already, in which he entertained his schoolfellows; and it was probably drawn from the recollection of himself at that time:—

"After reading a few books, I was seized with the desire to narrate, to gratify the passions of my youthful auditors. I gradually began to invent, and form stories of my own. Perhaps this passion has produced all my originality. I never loved to imitate, but always to invent: this has been the case in all the sciences I have studied."

Of the many remarks written at this period which

occur scattered through his note-books, I shall select a few as specimens of his modes of thought, some of a miscellaneous nature, some relating to science and philosophy: —

"General terms — what some metaphysicians have called abstract ideas — arise from the association of analogy by a very simple operation — not, as Jean Jacques Rousseau supposed, by a very complicated one.

"No metaphysical system, and, indeed, no system can be any thing more than a history, — not in the order of impression, but in the order of arrangement by analogy.

"Atheism the necessary consequence of materialism.

"Consistency in regard to opinions is the slow poison of intellectual life — the destroyer of its vividness and its energy.

"We are accustomed to consider thought and language as almost synonymous. What an immensity of feelings, what an innumerable quantity of perception, must necessarily impress the mind of all men. Writing and speaking are arts, like music and painting, to express some of them only.

"Our opinions are much oftener formed by our feelings, and modified by them, than our feelings by our opinions: arguments in general an instance of this. Passion, or uneasy feeling, produces assents or dissents of different kinds.

"Our actions are neither the result of feelings or opinions; they are modified by them both, but are produced by habits.

"What is imagination? Almost always the recurrence of remembered visible imagery, under the influence of hope or fear.

"Almost all great deeds arise from a plenitude of hope or desire. No man ever had genius who did not aim to execute more than he was able.

"The sciences and the arts ought to be considered as related to man only so far as they are capable of promoting his happiness. Our knowledge of their capabilities must be founded upon an estimate of the powers and faculties of the human mind, and the sources of enjoyment which are within the reach of these faculties and powers.

"Philosophy is simple and intelligible. We owe confused systems to men of vague and obscure ideas.

"We ought to reason from effects alone. False philosophy has uniformly depended upon making use of words which signify no definite ideas.

"Our knowledge is little indeed: and scepticism in regard to theory is what we ought most rigorously to adhere to.

"Experimental science hardly ever affords us more than approximations to truth; and whenever many agents are concerned we are in great danger of being mistaken.

"Theories ought to be made for time, and be considered capable of improvement.

"That man must indeed be badly organised whom nature is incapable of instructing. The theorising habit in a sound mind can counteract only for a short time the love of seeing things in their real light; and the illusions of the imagination, in proportion as they often occur and are destroyed by facts, will become less vivid and less capable of permanently misleading the mind.

"The feeling generally connected with new facts enables us to reason more rapidly upon them, and is peculiarly active in calling up analogies.

"In physical science the imperfections of our instruments of investigation, the fallacies to which we are liable from the modifications of impressions by the state of feeling, and the minute nature and the complicated relations of the objects of research, prevent us from attaining to that state of certainty afforded by the results of the science of quantity. The physical sciences involve the universe, man, and nature, in all their modifications, and all their newly acquired powers. They are at once the instruments and subjects of examination. Probabilities are the most we can hope for in our generalisations; and whenever we can trace the connection of a series of facts, without being obliged to imagine certain relations, we may esteem ourselves fortunate in our approximations.

"One use of physical science is, that it gives definite ideas."

I shall give one fragment more, indicating the desire he then felt to benefit mankind, and which, to the last, never forsook him:—

"Shall those arts which have discovered a thousand instruments for inflicting pain or suffering on civilised man never discover any new means of making him happy? Shall the fruit of the tree of knowledge always continue bitter; shall it never be ripened by the radiance of the sun of benevolence? If there be any sufficiently cold-hearted to believe this, let them remain idle. To us hope, which, though it should be vain, is yet an eternal source, will remain; it will ever prompt to actions which, though they should deserve no laurels of triumph from mankind, will never have raised them by watering the earth with blood."

The quantity of poetry which he composed at this time was small; he was too much devoted to physical

research to give much of his time to the Muses; and when he did address them, he seemed to think some apology was necessary. Thus, in a letter accompanying some lines on St. Michael's Mount (which were published in the "Annual Anthology"), he writes to his mother: — "I have sent you with this some copies of a poem on the place of my nativity; but do not suppose I am turned poet. Philosophy, chemistry, and medicine are my profession. I had often praised Mount's Bay to my friends here: they desired me to describe it poetically." Yet, at times, I believe, he meditated some serious and long-continued exertion in these imaginative regions. This I infer from letters to him from his poetical friends, which I have heard spoken of, and from a distinguished one in particular, proposing to him a joint work, a philosophic epic; and it may be inferred, also, from some fragments which remain in note-books of this period, of a poem in blank verse, the subject of which was, the deliverance of the Israelites from Egypt, to have been named "Moses." The following is a verbatim copy of its plan, and of the characters which were to be introduced into it: —

MOSES.

BOOK I.

"Zipporah, and the six Daughters of Jethro, Priest of Midian, in watering their Father's Flock, are insulted by some Shepherds: Moses protects them, and assists them in watering their Flocks. — They take him to their Father's Dwelling. — Description of Pastoral Scenery. — Of the Patriarchal Manners. — Jethro, a Man of Energy, receives Moses with Affection.

BOOK II.

" The great Festival of the God of Nature. — Customs of the Midianites. — Moonlight Scene, and Reflections of Jethro on the System of the Universe. — History of Moses. — His earliest Impressions connected with Pharaoh's Daughter. — His Knowledge of his Family, &c.

BOOK III.

" Growing Love of Moses and Zipporah. — Moses agrees to stay with Jethro. — Their happy Pastoral Life. — Moses, in wandering in the Desert, falls down a Cataract. — Meets with Miriam. — She tells him of a Light of Glory surrounding his Body: believes himself under the immediate Inspiration of the Deity. — His Dreams. — Theory of Jethro. — He resolves to return to Egypt.

BOOK IV.

" Meets Aaron. — Sees his Mother. — Secret Conference at the Pyramids. — Goes and speaks to Pharaoh, who was the Companion of his Youth. — Jacobinical Sentiments. — Pharaoh calls the Magicians (Reference to these in Book II.). — Visits Pharaoh's Daughter. — She supplicates him. — The Plagues. — Lamentation for the Death of the First Born.

BOOK V.

" March through the Desert. — Miraculous Appearance of the Son of God. — Destruction of Pharaoh and his Army. — Moses' Song. — Amalek overcome.

BOOK VI.

"Meeting of Jethro. — His Counsels. — Institution of Laws. — Communion with God on Mount Sinai. — Mosaic Account of Creation. — End.

"Moses a great but enthusiastic Man. — Zipporah his Superior in reasoning Powers and in Sensibility. — Pharaoh a Despot. — Jethro a Wonder, a philosophic Priest. — Joshua a Hero, *i. e.* a Murderer. — Hur. — Miriam the Prophetess, the Sister of Moses, a wonderful Woman."

We have here a subject admirably adapted to the epic, and a plot abounding in all the circumstances most fitted to excite poetical interest, both in the writer and the reader. Had my brother applied all the powers of his mind to the work, I cannot but think he would have given to the world a poem that would have afforded delight and instruction — delight, even had it been struck off in the heat of a youthful imagination; and instruction, could he have had the resolution to have suspended its publication till it could have been corrected by his maturer judgment. But these are vain speculations; his genius was destined for other efforts. Some specimens of the composition which remain in the form of fragments I shall introduce. They may amuse the reader; and they show, if I am not mistaken, that he had not engaged in a theme beyond his powers: —

"And loud she struck the harp, and raised the song,
Her ebon tresses waving in the wind;
Her dark eye sparkling, and her bosom
Throbbing with transport high. — 'Thou, thou art he,
The chosen one of God, — the man foretold
The saviour of thy people. Prophet, chief,
And lawgiver of Israel! at thy birth
Deliver'd to the waters, yet preserved,
By hand unhallow'd, — from the royal pomp

Of Pharaoh, and the dark idolatry
Of Egypt's kingdom led to know thy God,
In nature and in solitude to feel
His mighty inspirations! Go then forth:
In all the high unbroken strength of hope
Proclaim the Eternal One, — declare his will.
Let Egypt and the kindred nations know
That *He alone* is God! — that He will free
In terror and in wrath his chosen seed,
Exalt the oppressed, tread the tyrant low,
And scatter as the sand upon the blast
The people that rebel against His will.
Go forth his servant, — go deliverer!"

"Oh, with what pleasure, with what strong delight
Does Nature, long subdued, imprison'd long,
By heavy action, and the cumbrous chains
Of earthly ceremony, assume her rights.
Like the mild zephyr of the full-born spring,
Succeeding to the frosty northern blast,
She felt that Nature meant her to perform
All soft and tender duties, — to become
A wife, a mother; that her heart was form'd,
Not for the dull, inert, and callous round
Of earthly forms and state, but soft and fill'd
With power, and with passion, to become
All natural sympathies, — to interweave
Itself with other hearts, — to glow with rapture
At another's joy, and melt in sorrow
At another's woes."

"Gently flow'd on the waters, as the sun
Shone on them in full brightness; the tall plants,
Shadowing around the little cradle, grew
In full luxuriance. Fishes sported in the wave,
Myriads of lovely insects fill'd the air,
And all she saw was life and happiness:
Her mind in deepest sympathy, —
'Shall all things live, and Thou, the masterpiece
Of all things living, perish?'"

"What are the splendid visions, and the hopes
Of future days, but renovated thoughts
And ancient feelings awaken'd into life
By some new accident, and tinged with hues
Bright in the glow of passion? Oh, my father!
In vain the aspiring spirit strives to pierce
The veil of Nature, dark in mystery;
In vain it strives, proud in the moving force
Of hopes and fears, to gain almighty power,

To form created intellectual worlds.
Its inborn images have all the stamp
Of outward things of sense. The priest's high God,
The Father of the thunder, He who dwells
In the blue heaven upon his throne of light;
The demon of the coward, and the form —
The angel form — that to the tear-wet eye
Of some devotion-smitten maid appears,
Are clad in all the attributes of man,
Distorted by the changeful influence
Of passion's dreaminess."

"But often in the heavens my wandering eye
Has seen the white cloud vanish into forms
Of strange unearthly lineaments.
And often in the midnight's peaceful calm
Have I been waked by strange unearthly tones,
And often in the hour of sacrifice
Felt strange ideal pleasures.
My son! I see thine eye is turn'd
Most doubtingly upon my countenance.
In youth the enthusiastic mind,
Or sees in all realities a dim
And visionary world; or hardy in
The plenitude of doubt, sees nothing
But that which sense affects."

"He felt a sentiment of pleasure thrill
Within his bosom, and the liberty
Of free unbiassed action sweeter seem'd
Than all the pomp and luxury of state
And chains of ceremony. The wild majesty
Of Nature in her noblest mountain garb
Came on his spirit.
On the wild rock, and on the palm-clothed hill,
And on the snowy mountain, Pleasure seem'd
To fix her dwelling-place, and Music moved
For him in every torrent's murmuring sound,
And balmy Sweetness dwelt in every breeze,
And every sun-beam minister'd to life."

A poem on St. Michael's Mount, written by him at this time, has already been alluded to, on account of the excuse which he made for it: its concluding stanzas are descriptive of the then bias of his mind:—

"Thus to the sweetest dreams resign'd
The fairy Fancy ruled my mind,
And shone upon my youth;

But now to awful reason given,
I leave her dear ideal heaven
  To hear the voice of truth.

"She claims my last, my loftiest song;
She leads a brighter maid along,
  Divine Philosophy,
Who bids the mounting soul assume
Immortal Wisdom's eagle plume
  And penetrating eye.

"Above Delusion's dusky maze,
Above deceitful Fancy's ways
  With roses clad, to rise
To view a gleam of purest light
Bursting through Nature's misty night,
  The radiance of the skies!"

Amidst his various pursuits at Clifton, all in accordance with his own tastes and wishes, rewarded by success in discoveries, by the approval and esteem of those around him, and by a reputation which few men so young ever earned, he appears to have passed a time of more than usual enjoyment, and to have indulged in sanguine hope, or rather assurance, of advancing fortunes in life, and of greater conquests in science. His letters home were strongly indicative of this happy state of mind. In one to my mother, he says, "We are going on gloriously; our patients are getting better; and, to be a little conceited, I am making discoveries every day." In another letter to her, speaking of Dr. Beddoes, he says, "You have been told he is fond of money; I assure you it is quite the contrary, he is good, great, and generous; and Mrs. Beddoes is the best and most amiable woman in the world. I am quite naturalised into the family, and I love them the more the more I know them." In another, after a visit to his friend, Mr. Gregory Watt, at Birmingham, he, as was usual with

him, couples the pleasure he experienced with praise of those whom he liked. He formed there an acquaintance with Mr. Keir, an able chemist, and distinguished for much originality and independence of mind. "I was particularly sorry," he says, "to leave him, for he is both an amiable and a great man."

His escape from the vices which are most seductive to youth in great cities, is feelingly described in the following fragment of a letter which exists in a note-book, addressed to one of his early home friends. Whether it was written at this exact time, or two or three years after, it is not easy to decide; an expression in it may seem to indicate a later period: but with him, who "lived intensely," months were as years.

"We can trace back our existence almost to a point: former time presents us with trains of thoughts gradually diminishing to nothing; but our ideas of futurity are perpetually expanding; our desires, and our hopes, even when modified by fears, seem to grasp at immensity. This alone would be sufficient to prove the progressiveness of our nature, and that this little earth is but the point from which we start towards a perfection that is bounded only by infinity."

After describing the different roads they were pursuing in life, he adds, "I do not always look back upon the interval that has elapsed since I left home, without shuddering at the dangers to which I have been exposed. I was at that age when the passions are most powerful; when ambition and folly, uncontrolled by experience, are the masters of the soul. Temptations speak every where to man in great cities,

which are the abodes of luxury and vice. An active mind, a deep ideal feeling of good, a look towards future greatness, has preserved me. I am thankful to the Spirit who is every where, that I have passed through the most dangerous season of my life with but few errors; in pursuits useful to mankind, pursuits which promise to me, at some future time, the honourable meed of the applause of enlightened men."

This prophetic feeling of distinction was soon about to be realised. The Royal Institution, a short time previously, had been founded after a plan of Count Rumford, with the intent of diffusing a knowledge of science, and of its applications to the common purposes of life, and of exciting a taste for science amongst the higher ranks. In consequence of the expected retirement of the professor of chemistry, Dr. Garnet, a successor was sought after; and it was my brother's good fortune to be invited to accept the situation. I use the words good fortune, rather in relation to his scientific career, for which it was an admirable field, than in a money-making or merely worldly acceptation. In Dr. Paris's "Life" of him, there are some details of the manner in which it is said he obtained the appointment, and through whose recommendation, and how the negotiation was carried on. His published labours, it may now be supposed, might alone have sufficed to recommend him, and, in all probability, they were the chief recommendation. In his own account of the transaction in his letters, written in confidence to my mother, he makes no allusion to any interest exerted in his favour, or acknowledges obligation to any individual for aiding in obtaining him the appointment.

He seems to have thought that he was invited because he was considered fitted for the situation; and no doubt the preference was given to him because he was considered best fitted for it. In a letter dated the 27th of September, 1800, in which he first alludes to his own prospects, he merely says, "My future prospects are of a very brilliant nature, and they have become more brilliant since I last wrote to you; but wherever there is uncertainty I shall refrain from anticipating." The following letter was written when the uncertainty was nearly at an end, and when the general terms of the appointment had been made on which he finally accepted it: —

"31st January, 1801.

"My dear Mother,

"During the last three weeks I have been very much occupied by business of a serious nature. This has prevented me from writing to you, to my aunt, and to Kitty. I now catch a few moments only of leisure to inform you that I am exceedingly well, and that I have had proposals of a very flattering nature to induce me to leave the Pneumatic Institution for a permanent establishment in London.

"You have perhaps heard of the Royal Philosophical Institution, established by Count Rumford, and others of the aristocracy. It is a very splendid establishment, and wants only a combination of talents to render it eminently useful.

"Count Rumford has made proposals to me to settle myself there, with the present appointment of assistant lecturer on chemistry, and experimenter to the Institute; but this only to prepare the way for my being in a short time sole professor of chemistry, &c.; an appointment as honourable as any scientific ap-

pointment in the kingdom, with an income of at least *500l.* a year.

"I write to-day to get the specific terms of the present appointment, when I shall determine whether I shall accept of it or not. Dr. Beddoes has honourably absolved me from all engagements at the Pneumatic Institution, provided I choose to quit it. However, I have views here which I am loath to leave, unless for very great advantages.

"You will all, I dare say, be glad to see me getting amongst the *Royalists*, but I will accept of no appointment except upon the sacred terms of *independence*.

* * * * * *

"I am your most affectionate Son,

"H. Davy."

This letter, as appears from its date, was written on the 31st of January. In the middle of February he went to London; and five days after he informs my mother, that he is "negotiating with Count Rumford concerning the professorship at the Royal Institution." He adds, "His proposals have not been unfair; and I have nearly settled the business." The arrangement finally made was almost precisely that first proposed. He returned to Bristol, to give over his charge of the Pneumatic Institution, and take leave of his kind and respected friends there; and in the following month he took up his abode in London.

CHAPTER III.

HIS RECEPTION AS A LECTURER AT THE ROYAL INSTITUTION.—SLANDEROUS CHARGES AGAINST HIM ANSWERED.—PROOFS OF HIS REGARD FOR OLD FRIENDSHIPS.—EXTRACTS EXPRESSING THE OPINIONS OF SOME OLD FRIENDS RESPECTING HIM.—CIRCUMSTANCES FAVOURING HIS SUCCESS IN LECTURING.—SPECIMENS OF HIS LECTURES.—HIS MANNER OF PREPARING AND DELIVERING THEM.

THE duties upon which he entered at the Royal Institution were those of assistant lecturer on chemistry, and director of the laboratory; but, according to the terms on which he accepted the situation, this was merely a temporary arrangement, and to last only till he had prepared himself for filling the higher appointment of professor of chemistry. In a letter to my mother, the last referred to, after specifying the conditions, he says, "I hope to be able to undertake the professorship next year;" and the next year he did undertake it. On the 31st of May, 1802, he was formally appointed to this office by a resolution of the managers.

In the spring of 1801, six weeks after his arrival, he gave his first lecture. I shall transcribe an account of it from the Philosophical Magazine, a contemporary journal. Under the head of the "Royal Institution of Great Britain," the editor remarks,—

"It must give great pleasure to our readers to learn that this new and useful institution, the object of which is the application of science to the common purposes of life, may be now considered as settled

on a firm basis. The lectures of Dr. Garnet have been such as do equal honour to the institution and the professor, and have been well attended.

"We have also to notice a course of lectures just commenced at the institution, on a new branch of philosophy; we mean the galvanic phenomena: on this interesting branch Mr. Davy (late of Bristol) gave the first lecture on the 25th of April. He began with the history of galvanism; detailed the successive discoveries, and described the different methods of accumulating galvanic influence.

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"Sir Joseph Banks, Count Rumford, and other distinguished philosophers, were present. The audience were highly gratified, and testified their satisfaction by general applause. Mr. Davy, who appears to be very young, acquitted himself admirably well. From the sparkling intelligence of his eye, his animated manner, and the *tout ensemble*, we have no doubt of his attaining distinguished excellence." *

Dr. Paris's account of my brother's first appearance is in a very different strain; and, to use an expression of his own, "written by no friendly hand nor honest chronicler." He speaks, apparently on the authority of Mr. Underwood, of my brother's unfavourable personal appearance, at the moment exciting regret in the mind of Count Rumford at having yielded to the application of friends in his favour; of his uncouth appearance and address subjecting him to various mortifications; of a smirk on his countenance, and a pertness in his manner; in brief, he so speaks of him as to make a very un-

* Phil. Magazine, No. xxxv. p. 281.

favourable impression on the mind of the reader, and to give pain to those who have any regard for his memory. Even if they were correct, it appears to me such particulars need not be recorded: it is ungenerously done, and in bad taste; and, if incorrect, the giving them is, in regard to biography, an unpardonable offence. It is in bad taste to associate the ludicrous and contemptible with science and genius; it is unworthy of the advocate of the interests and dignity of science, for it is most injurious to them both, the more especially if done merely in jest.

The quotation I have already given is sufficient proof, I trust, that I am not complaining in this instance of Dr. Paris without just grounds. Were it necessary, other proof to the same effect might be adduced. I might refer the reader to Mr. Poole's letter to Dr. Paris, which will be given in the sequel, in which he mentions my brother's "interesting conversation, manners, and appearance," when he first became acquainted with him in 1799. I might refer the reader to another letter to Dr. Paris from the same gentleman, of which he favoured me with a copy, with his sanction to use it, written after reading Dr. Paris's work. The following are Mr. Poole's words: — "You will excuse my making two or three remarks. I do not think you have done justice to Sir Humphry's appearance and manners in early life. Though his manners were retreating and modest, he was generally thought naturally graceful; and the upper part of his face was beautiful. I remember, when he first lectured at the Royal Institution, the ladies said, 'Those eyes were made for something besides poring over crucibles.'"

This allusion to his face was probably made in consequence of another statement of Dr. Paris, who, after a most unfavourable account of his youthful appearance, proceeds: "In riper years he was what might be called good-looking, although, as a wit of the day observed, 'his aspect was certainly of the bucolic character;'" and he adds, "The change which his person underwent after his promotion to the Royal Institution was so rapid, that, in the days of Herodotus, it would have been attributed to nothing less than the miraculous interposition of the priestess of Helen." This is as foolish as it is unfounded and unworthy of remark. No authority is given for the ridiculous assertion; and all the authenticated notices Dr. Paris introduces of his personal appearance and manner when he commenced his career in London are in opposition to it. Such, we have seen, is Mr. Poole's notice of him; such that of the editor of the Philosophical Magazine written at the time; and such, also, is that of Mr. Purkis. "The sensation created by his first course of lectures at the Institution," says Mr. Purkis, "and the enthusiastic admiration which they obtained, is at this period hardly to be imagined. Men of the first rank and talent; the literary and the scientific, the practical and the theoretical; blue stockings, and women of fashion; the old and the young; all crowded, eagerly crowded, the lecture room. His youth, his simplicity, his natural eloquence, his chemical knowledge, his happy illustrations, and well-conducted experiments, excited universal attention and unbounded applause. Compliments, invitations, and presents were showered upon him in abundance from all quarters; his society was courted by all,

and all appeared proud of his acquaintance."* This last is given by Dr. Paris himself, and is taken from his work: — "By his own words shall he be judged."

Had Dr. Paris confined himself to animadversions on my brother's person merely, they might have been passed by without comment; but he proceeds farther, and takes as great liberties with his moral character; which he describes as suddenly and almost preternaturally changing for the worse, as he had imagined before that his personal appearance did for the better. In one place, Dr. Paris, after pointedly noticing his eminent success in his earliest efforts as a lecturer, even in language more glowing and strong than Mr. Purkis himself, says, "It is admitted that his vanity was excited, and his ambition raised, by such extraordinary demonstrations of devotion; that the bloom of his simplicity was dulled by the breath of adulation; and that, losing much of the native frankness which constituted the great charm of his character, he unfortunately assumed the garb and airs of a man of fashion."

Various other charges are brought against him in the same offensive tone, scattered, with marvellous inconsistency, throughout Dr. Paris's book; as rudeness of manner, flippancy, an inordinate admiration of hereditary rank, arrogance, and neglect of friends. I shall extract one passage more, as a specimen in which the saying of a gentleman, who was once my brother's friend, but who had become cold towards him, is professedly reported. Dr. Paris repeats, "It has been stated, that, shortly after Davy's successful

* Dr. Paris's "Life," &c. p. 90.

début as a lecturer, his manners underwent a change; and that, to the regret of his friends, he lost much of his native simplicity. On the 5th of February, 1802, he had dined with Sir Harry Englefield at his house at Blackheath; and eighteen years afterwards, the worthy Baronet alluded to his interesting demeanour on that occasion in terms sufficiently expressive of his feelings, — "It was the last flash of expiring nature." If this *were* said, I may remark it carries its own condemnation along with it, as a monstrous hyperbole; and it was as unkindly noted down as it is unkindly related, even if we suppose there had been any foundation for it: I say *noted down*, because Sir Henry Englefield died in 1822*, nine years before Dr. Paris's book was written.

As I have availed myself of Mr. Poole's letter to Dr. Paris to repel one species of attack, I gladly have recourse to the same authority in vindication of my brother's moral character. The general tenor of his remarks in the letter already alluded to, is eminently fitted for the purpose; and another letter, also referred to, of Mr. Poole to Dr. Paris, is equally so in regard to one special charge. He says, "You seem to imply, as his celebrity increased, that he in some measure discarded his old friends. I always loved him for his fidelity to his early friends. When a man has a hundred calls on his attention, he cannot give as much to each as when he had only ten."

How does my brother write to Mr. Poole, a little more than a year after the time that nature is as-

* That year my brother, in his official capacity as President, pronounced this gentleman's eulogium before the Royal Society, as if they had always been friends.

serted to have expired in him? I quote from Dr. Paris's book: —

"*To Thomas Poole, Esq.*

"London, May 1. 1803.

"My dear Poole,

"Have you no thoughts of coming to London? I have always recollected the short periods that you have spent in town with a kind of mixed feeling of pleasure and regret.

"In the bustling activity occasioned in cities by the action and reaction of diversified talents, occupations, and passions, our existence is, as it were, broken into fragments; and with you I have always wished for unbroken intercourse, and continuous feeling.

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"Be not alarmed, my dear friend, as to the effect of worldly society on my mind: the age of danger has passed away. There are in the intellectual being of all men paramount elements, certain habits and passions, that cannot change. I am a lover of nature with an ungratified imagination. I shall continue to search for untasted charms, for hidden beauties. My *real*, my *waking* existence, is amongst the objects of scientific research. Common amusements and enjoyments are necessary to me only as dreams to interrupt the flow of thoughts too nearly analogous to enlighten and to vivify.

* * * * * *

"Your affectionate friend,

"Humphry Davy."

How does he write to Mr. Clayfield, in 1804, on

the death of his early friend, Mr. Gregory Watt? I shall quote again from Dr. Paris:—

"I scarcely dare to write upon the subject. I would fain do what Hamlet does when, in awe and horror at the ghost of his father, he attempts to call up the ludicrous feeling; but, being unable to do so, he merely employs the words which are connected with it. I would be gay, or, I would write gaily, in alluding to the loss we have both sustained; but I feel that it is impossible. Poor Watt! He ought not to have died. I could not persuade myself that he would die; and until the very moment when I was assured of his fate, I would not believe he was in any danger.

"His letters to me only three or four months ago were full of spirit, and spoke not of any infirmity of body, but of an increased strength of mind. Why is this in the order of nature, that there is such a difference in the duration, and destruction of her works? If the mere stone decays, it is to produce a soil which is capable of nourishing the moss and the lichen; when the moss and the lichen die, and decompose, they produce a mould, which becomes the bed of life to grass, and to a more exalted species of vegetables. Vegetables are the food of animals; the less perfect animals of the more perfect; but in man the faculties and intellect are perfected. He rises, exists for a little while in disease and misery; and then would seem to disappear, without an end, and without producing any effect.

"We are deceived, my dear Clayfield, if we suppose that the human being, who has formed himself for action, but who has been unable to act, is lost in the mass of being; there is some arrangement of

things which we can never comprehend, but in which his faculties will be applied.

"The caterpillar, in being converted into an inert scaly mass, does not appear to be fitting itself for an inhabitant of air, and can have no consciousness of the brilliancy of its future being. We are masters of the earth; but, perhaps, we are the slaves of some great and unknown beings. The fly that we crush with our finger, or feed with our viands, has no knowledge of man, and no consciousness of his superiority. We suppose that we are acquainted with matter, and with all its elements; and yet we cannot even guess at the cause of electricity, or explain the laws of the formation of the stones which fall from meteors. There may be beings, thinking beings, near us, surrounding us, which we do not perceive, which we can never imagine. We know very little; but, in my opinion, we know enough to hope for the immortality, *the individual immortality of the better part of man.*

"I have been led into all this speculation, which you may well think wild, in reflecting upon the fate of Gregory! my feeling has given erring wings to my mind. He was a noble fellow, and would have been a great man. Oh! there was no reason for his dying — he ought not to have died.

"Blessings wait on you, my good fellow! Pray, remember me to Tobin; and, if you read this letter to him, protest the moment he begins to argue against the immortality of man."*

How does he write to his early friend, Mr. Clayfield, in 1812, from a remote part of the Highlands?

* Dr. Paris's "Life," &c., p. 128.

"Dunrobin, near Golspie, August 28.

"Dear Clayfield,

"I am much obliged to you for two very kind letters, and for a box containing specimens from St. Vincent. I beg you will thank the gentleman who was so good as to cause them to be collected for me. The box followed me to Inverness. The ashes, I think, are likely to fertilise Barbadoes. There is a parallel case of materials having been carried so far in the eruption in Iceland, in 1783.

"I have been with my wife, making a tour through the north, since the beginning of July. We have arrived at our extreme point, and shall slowly proceed south in about a fortnight.

"I wish you could be of our party here. We are in a delightful house, that of Lord Stafford, in a country abounding with fish and game. I have caught about thirty salmon since I came here, and killed grouse, wild ducks, teal, &c. I have not yet shot a stag, but I hope to do so this next week.

"I have just published a volume of the 'Elements of Chemistry,' and I hope to publish another in the course of the spring. Having given up lecturing, I shall be able to devote my whole time to the pursuit of discovery. I have not sent you a copy of my book, for I have thought that the best mode of avoiding giving offence to some, was by not making presents at all. Had I not so determined, one of the first copies would have been sent to you, as a mark of the warm esteem and regard of

"Your affectionate friend,

"H. Davy."*

* Dr. Paris's "Life," &c., p. 222.

How to Mr. Purkis, from the same place?—

"Dunrobin Castle, August 29. 1812.

"My Dear Purkis,

"You may probably be surprised to receive a letter from me from this remote corner of the north; but I owe you a letter, and I have a great inclination, wherever I may be, to discharge all debts, and particularly those rendered due by kindness.

"Receive my warm acknowledgments for your kind congratulations on my becoming a Benedick. I can now speak from experience, in which you have long participated. I am convinced that the natural state of domestic society is the best fitted for man, whether he be devoted to philosophy, or to active life.

"I shall have much pleasure in presenting my wife to you and to Mrs. Purkis on my return.

"We have had a delightful tour through the Highlands. We are at the extreme point of our journey. The pleasures of a refined society, that of Lord and Lady Stafford's family, have induced us to make a long pause here. We think we shall be in London in the beginning of December.

"I have spent some days such as we passed together in Wales; but the glens of the principality may fairly stand in competition with those of the Highlands.

"I hope I shall find you and your family in good health, and that you will have spent a very pleasant summer. I am, my dear Purkis,

"Very sincerely and affectionately yours,

"H. Davy."*

* Dr. Paris's "Life," &c., p. 223.

How to his family? Many letters might be given in proof of his uninterrupted natural affection: I shall here limit myself to one to my youngest sister: —

"January 2. 1806.

"My dear Sister,

"I wish I had a flying wooden box, such a one as you have read of, or ought to have read of, in the 'Arabian Nights' Entertainments;' for then I would come and see you every morning, and take you an airing about the world, and show you all the great cities, and great sights, people long so much to visit, and so soon grow tired of when they are wise.

"But you are happier than if you were a traveller; and, I am sure, happier than if you were with Kitty in London; for you are contented, and living with old friends, whom, I am sure, you will always be wise enough to prefer to new ones. You do not know how much I was delighted with what I saw of your conduct whilst I was at home. Your strong affection for my mother, your love for John, your attention to all your duties, gave me the warmest pleasure. I hope you will always be as good, and as unaffected, and as happy as you are now; and that you will enjoy all the blessings that Heaven can bestow upon you.

"I trust, my dear girl, that you will endeavour to improve yourself in writing, and that you will persevere till you can spell and write very correctly. I shall be very glad to have you for a correspondent; and I will answer every correct and well-written letter that you send me.

"I enclose a one-pound note, which you will lay out in books, or in any thing else that you like. I enclose another one-pound note, which I wish to have

disposed of in the following manner, for me:—To Mary Launder, 5*s.*; to Betty White, 5*s.*; and with the rest you will buy some ribbands, or little articles of dress for the Doctor's Jenny, my aunt Sampson's Phillis, my aunt Millet's maid, and my mother's servant, as new year's gifts.

"I am, dear Betsy,

"Your affectionate Friend and Brother,

"H. DAVY."

To whom does he dedicate his last works? One he dedicates to Dr. Babington, "in remembrance of some delightful days passed in his society, and in gratitude for an uninterrupted friendship of a quarter of a century;" and the other to Mr. Poole, "in remembrance of thirty years of continued and faithful friendship."

What does Mr. Knight say of him? who had known him almost as long as Mr. Poole, and who was in the habit of meeting him in the circles of science, as well as of fashion, in the metropolis, and of receiving his visits in his own beautiful country retirement. I shall again quote from Dr. Paris:—

"My late lamented friend, Sir Humphry Davy, usually paid me a visit in the autumn, when he chiefly amused himself in angling for grayling, a fish which he appeared to take great pleasure in catching. He seemed to enjoy the repose and comparative solitude of this place, where he met but few persons, except those of our own family; for we usually saw but little company. He always assured me that he passed his visits agreeably; and I have reason to believe he expressed his real feelings. In the familar conversations of those friendly visits, he always appeared to

me to be a much more extraordinary being than even his writings and vast discoveries would have led me to suppose him; and in the extent of intellectual powers, I shall ever think that he lived and died without an equal."*

Lastly, whom did he remember in his will, and to whom did he bequeath tokens of affection? Out of his own family, they were chiefly his early friends: as Mr. Poole, Dr. Babington, Mr. Pepys, Dr. Frank, Sir B. Brodie, and two or three more, from whom he had received kindnesses in later life, as Dr. Morichini of Rome, and Monsignor Spada Medici.†

There might have been, and I believe there were, two or three instances of individuals, to whom he had a very friendly feeling in youth, which he did not retain in his mature age — not in consequence of fickleness of disposition, or fault on his part, but owing to change in them, or conduct which did not meet his approval. I shall mention only one in particular, — Mr. Underwood, an artist of some talent, with a fondness for science, from whom Dr. Paris appears to have received very many unfavourable notices of my brother, incidents and anecdotes, which, even if true, no true friend would have communicated of another. Witness the letter which Mr. Underwood communicated, written by my brother, evidently in a moment of enthusiasm and friendly confidence, and which Dr. Paris calls "a

* Dr. Paris's "Life," &c., p. 203.

† This most amiable and accomplished man was noticed in a letter from my brother, dictated when he supposed himself dying, — the same letter in which he requested that 100*l*. should be given to the Grammar-School of Penzance on the condition of the boys having a holiday annually on his birthday. The bequest to Monsignor Spada was a gold snuff-box which he forwarded himself to him.

composition of much wildness, and obnoxious to the suspicion of Spinozism;" with how much propriety, I shall leave to the candid reader to decide, if there is any candid reader who attaches importance to a careless effusion of youthful feeling:—

"My dear Underwood,

"That part of Almighty God which resides in rocks and woods, in the blue and tranquil sea, in the clouds and sunbeams of the sky, is calling upon thee with a loud voice,—religiously obey its commands, and come, and worship with me, on the ancient altars of Cornwall. I shall leave Bristol on Thursday next, possibly, before; so that by this day week I shall, probably, be at Penzance. Ten days or a fortnight after, I shall expect to see you, and to rejoice with you.

"We will admire together the wonders of God,—rocks and the sea,—dead hills, and living hills, covered with verdure. Amen. Write to me immediately, and say when you will come. Direct, H. Davy, Penzance. Farewell, being of energy!

"Yours, with unfeigned affection,

"H. Davy."*

Witness Mr. Underwood's anecdote, of the difficulty which, he says, my brother experienced, on first going to London, in answering, to his own satisfaction, an invitation to dinner; a difficulty which most young men have probably experienced on first coming out into the world, merely from an ignorance of forms of etiquette, and which most affects sensitive minds.† Witness the various anecdotes which Mr.

* Dr. Paris's "Life," &c., p. 82. † Idem, p. 81.

Underwood gives of him during his visit to Paris in 1813, such as his contempt of the fine arts in the galleries of the Louvre (which I cannot credit, for he had a sincere admiration of fine art, — his contempt, I believe, was confined to the cant of artists);—his sudden, capricious, and violent "likes and dislikes;" — the conversion of his friendly feeling towards M. Ampère, some years after, into one of bitter aversion, which I do not believe true * ; — Mr. Underwood's idle story of my brother's testifying superstitious dislike at seeing a knife and fork placed crosswise on a plate at dinner † ;

* When I was in Paris, in the latter end of 1826, this gentleman expressed great regard and respect for my brother, and sent by me to him copies of some of his recent productions ; and towards M. Ampère I never heard my brother express the least hostile feeling ; nor is there such feeling expressed in a sketch of his character, written during the last year of his life, amongst the characters of distinguished men of his own time whom he had known.

† If he had a tincture of superstition, it was not in the vulgar sense ; but with philosophical views, arising out of the limited nature of human knowledge, his acquaintance with the wonders of nature, and a belief, founded on both, that there may be in the economy of nature circumstances necessarily or constantly associated, that is, in the relation of cause and effect, which are not yet understood, and which the half-informed and conceited laugh at, and pronounce monstrous or impossible. In his "Salmonia" he says, in the person of Physicus (he was then expressing his own sentiments on the subject), in reply to a remark of Hallieus, that he had known minds of a very superior class, persons in the habit of reasoning deeply and profoundly, affected by what are commonly considered superstitions. In reply, he says, "In my opinion, profound minds are the most likely to think lightly of the resources of human reason: it is the pert superficial thinker who is generally strongest in every kind of unbelief. The deep philosopher sees chains of causes and effects so wonderfully and strangely linked together, that he is usually the last person to decide upon the impossibility of any two series of events being independent of each other ; and in science so many natural miracles, as it were, have been brought to light, — such as the fall of stones from meteors in the atmosphere, the disarming a hunder cloud by a metallic point, the production of fire from ice by a metal white as silver, and referring certain laws of motion of the sea to the moon, — that the physical inquirer is seldom disposed to assert confidently on any abstruse subject belonging to the order of natural things ; and still less so on those relating to the more mysterious relations of moral events and intellectual natures."

—the statement of his flippancy of manner, and superciliousness of deportment towards French men of science, which I consider as a fiction, and which is attempted to be defended by Dr. Paris in a very strange and offensive way; and, lastly, the detail of minute and most trifling circumstances, in which it is supposed my brother gave offence, — such as his not rising from his chair, or saluting one of the most distinguished members of the Institute.

That my brother had ceased to esteem Mr. Underwood in the latter part of his life, I am well informed; indeed, he refused to see him when he called on my brother, during his illness at Rome, when I was with him. This I should not have considered myself justified in noticing, had not Mr. Underwood been instrumental, as appears from Dr. Paris's book, in casting a stain on his moral character, which as far as lies in my power it is my duty to remove. On this subject, I should have supposed that the evidence of such men as Mr. Poole and Mr. Knight might have more than balanced, with an impartial biographer, that of Mr. Underwood, who during the last thirty years has lived abroad, and in circumstances unfavourable for improving his judgment of human nature, at least in its noblest exertions in freedom, and without disguise.

This may suffice at present: further on I shall revert to the topic; and, as I proceed, I shall have occasion to bring forward evidence on evidence in opposition to Dr. Paris's allegation, or hypothesis, of the deterioration and fall of my brother's moral qualities with the improvement and exaltation of his intellectual powers and rank in society.

It is now time to advert more particularly to the

great success of his early lectures. The following letter, written in January, 1802, when, to use an expression of Sir Harry Englefield's, he was "covered with glory*," at the beginning of his second course, expresses very modestly his own feeling of satisfaction at the manner in which his exertions were received, and how, even at this time, when there was so much to divert his attention from his distant home, his affections kindled at the recollection of home; and this at the very time when they were supposed to be expiring: —

"London.

"My dear Mother,

"I have been very busy in the preparation for my lectures; and for this reason I have not written to you. I delivered my second lecture to-day, and was very much flattered to find the theatre overflowing at this, as well as at the first. I am almost surprised at the interest taken by so many people of rank, in the progress of chemical philosophy; and I hope I am doing a great deal of good, in being the means of producing and directing the taste for it.

"I have been perfectly well since I visited Cornwall; and I enter upon my campaign in high health and spirits. After four months of hard but pleasant labour, I shall again be free!

"I hope you are all well. I very often reflect upon the times that are past; and my mind is always filled with gratitude to the Supreme Being, who has made us all happy; and that, in placing us in distant parts, and in different circles, neither our feelings or affections have been disturbed.

* Dr. Paris's "Life," &c., p. 89.

"My predictions with regard to invasion, you will find, have been so far fulfilled. God has not intended this favoured island to be desolated by unprincipled ruffians; nor has he intended that the great, the good, and the brave amongst our countrymen should be placed upon a level, and brought into the field to meet the banditti of France,—

* * * * * *

"I shall be very glad to see you again. I intend, in June, to pass through Scotland, and to visit the Western Isles; but I hope I shall spend a part of the autumn with you.

"Pray write to me, and give me a little news. Beg Kitty, and Grace, and Betsy, and John to recollect me. I am, my dear mother,

"Your very affectionate son,

"H. Davy."

Dr. Paris, I perceive, adopts an opinion from Mr. Underwood, that my brother was mainly indebted for his early popularity as a lecturer at the Royal Institution to an anti-royal coterie, of the "most violent republicans of the day," called the "Tepidarian Society," from the potations at their meetings being confined to tea. He says, "The Tepidarians exerted all their personal influence to obtain an audience, before the reputation of the lecturer could have been sufficiently known to attract one."* This, I may remark, is of a piece with many other of his inconsistent assertions, as if the few members of this comparatively humble and little-known society, which held its meetings at Old Slaughter's Coffee-house, in St.

* Dr. Paris's "Life" &c., p. 80.

Martin's Lane, had a superior influence in the world of fashion to that of the aristocracy which founded and supported the Royal Institution. If we are to be guided by probabilities in our reasoning, it is more probable that the exertions of such a society, if their principles were known, would have been injurious to his reputation and name. His own principles were certainly very different from theirs, as the preceding letter to my mother sufficiently indicates. I never heard him mention this society; and I suspect, if he ever belonged to it, it was only whilst he was ignorant of their ultra principles.

His success as a lecturer was owing to far different causes, such as those pointed out by Mr. Purkis: "His youth, his simplicity, his natural eloquence, his chemical knowledge, his happy illustrations, and well-conducted experiments." To which may be added other circumstances connected with the Institution; the period and the state of science, all of an auspicious kind. The Royal Institution was a new experiment. Novelty in itself is delightful, especially to people of rank and fortune, who at that time, in consequence of the Continent's being closed, owing to the war, must have been delighted to have had opened to them a new and unexpected source of interest, fitted to amuse those who were suffering from *ennui*, and to instruct those who were anxious for instruction. The Royal Institution, moreover, was the creation of a large number of influential persons, both in the higher ranks of society, and of science. This alone might have sufficed to render it fashionable, and, if fashionable, popular. The period, morally and politically considered, aided the effect: a time of great political excitement had just terminated; a time of gloom

and despondency was then commencing. Whatever diverted the public mind, and afforded new objects of contemplation, pure and independent sources of amusement and gratification, must have been very welcome to all reflecting persons, even without taking into account the possible and probable good which might be conferred by the Institution on society, in accordance with the intentions with which it was first established: and the state of science generally, and especially of chemical science, was, perhaps, the most auspicious circumstance of all. It had passed the stage of feeble infancy; it was just entering on that of vigorous youth; it was sufficiently advanced to display much beauty, and to excite deep interest; and it was not too much advanced to be beyond the comprehension of minds of ordinary powers devoting to it a moderate portion of time. Besides, chemistry had just then begun to form connections, which immediately enhanced its value and attractions, particularly with mineralogy and geology, with vegetable and animal physiology, and with the useful arts of life. It had served to explain the formation of basalt and of marble; and it was confidently expected that it would throw much light on the structure and formation of our globe generally. It had elucidated one function of plants and animals — the important one of respiration; and it was hoped that it might be extended, in a similar manner, to the other functions of animal and vegetable life. It had afforded a rational theory for many of the arts, and had contributed to improve many of them: the steam-engine it had perfected; the balloon and diving-bell were essentially chemical inventions: there appeared no limits to the extension of its usefulness. Lastly,

I may allude to its connection with imponderable substances, as with light, heat, electricity, and especially that form of electricity which had just then been discovered — galvanism, which, more than all the rest, was destined to increase the interests and extend the dominions of chemistry, and enlarge the circle of human knowledge.

Here are circumstances amply sufficient to account for his rapid and brilliant success at the Institution, as lecturer, without having recourse, with Dr. Paris, to the aid of a Tepidarian Society; and if I am not mistaken, this will appear more manifest from the specimens of his lectures which I now propose to submit to the reader, and which I shall select from the MS. collection in my possession. In making the selection, it will be advisable to observe some order, and rather in regard to the subject, or matter, than the time. I shall first give some specimens to show his power of exciting the interest of a mixed audience; secondly the facility, and I may say felicity, with which he inculcated philosophical doctrines, the philosophy of science, and the methods of scientific research; thirdly, how he added to the interest of his subject, and enforced the doctrines by biographical notices, in giving which he was most generous of praise, and as sparing of censure as if he had considered the illustrious scientific discoverers who had preceded him in the light of parents, to whom a debt of gratitude, as from a son to a father, was owing, and a tender respect; and, fourthly, I shall advert to his manner of treating the sciences which he taught; how he blended the new with the old; and, by transferring the results of the laboratory to the theatre, in all their freshness, im-

parted to his lectures much of the charm and vigour of original discourses; by which means he was enabled to fix the attention even of the philosopher and man of science.

An "Introductory Lecture for the Courses of 1805" is the earliest lecture in MS. which has been preserved: both from its appellation and matter, it was evidently delivered at the commencement of the session, at the Royal Institution; and was not an introduction to his own lectures in particular, but to the lectures generally, on various subjects of science, literature, and the arts, which were to be given during the season. I shall insert the whole of it. It is peculiar in manner, and in tone, and peculiarly his; and adapted — not only at the time it was delivered, but in all times — to excite a taste for scientific pursuits, and stimulate intellectual exertion; and it offers a powerful defence of the interests of science in immutable connection with the best interests of society: —

"INTRODUCTORY LECTURE FOR THE COURSES OF 1805.

"The love of knowledge and of intellectual power is a faculty belonging to the human mind in every state of society; and it is one by which it is most justly characterised — one the most worthy of being cultivated and extended.

"Useful to the individual, and even necessary to his existence, its general effects upon the species are in the highest degree important and beneficial; and the improvements in the condition and in the happiness of mankind appear in all instances to have preserved an uniform pace with the progress of the in-

ventions of the arts, and the advancement in the sciences.

"This truth scarcely requires any demonstration. To prove it, there is no necessity for recurring to any refined arguments: the mere comparison of the rude, and of the cultivated state of society, must carry conviction to every unprejudiced understanding. In the dreams of a brilliant imagination, indeed, the uncivilised state of man may appear in high and vivid tints of happiness; and the fancy of an enthusiast may enable him to draw strong contrasts between nature and art unfavourable to the latter; between blue skies, verdant groves, murmuring streams, the scenery of a mountain country, and the smoke and dirt of towns, the noise and bustle of commerce, and the insipidity of productive plains; between the earth wildly and spontaneously producing food, and grounds made fertile only by human labour; between the vices, miseries, and dependance of man in society, and his simple virtues, his lofty pastoral manners, and his unsubdued freedom in the condition of nature.

Such romantic pictures, though they should be adorned with the highest colouring of genius, can, however, scarcely in the slightest degree affect the opinion of sound and judicious reasoners. The details of past times, the narrations of travellers, or even a simple observation of the habits and propensities of the human mind, are sufficient to demonstrate that its highest enjoyments are connected with an active state of the understanding, and an exalted social intercourse, — are sufficient to demonstrate that the being whose pleasures are only produced by the gratification of his common wants, and whose wants

are constantly limited by the poverty of nature, can never be justly opposed to the man whose delights are in a great measure conformable to his wishes; whose intellectual gratifications are even more numerous than his appetites, and whose mind is the *master* of his body, and not its *slave*.

"Many speculative men, whose minds have been awake to the advantages of improvement, have nevertheless conceived that, in all cases, there must be certain limits to the progress of civilisation, — have conceived that the sciences and the arts, however beneficial in their first effects, must finally tend to enfeeble the character, and to promote the increase of luxury. Such persons have generally founded their opinions upon incorrect views of the history of ancient nations; and, haunted by ideas of their rapid elevation and downfall, have believed that the same powers operate in modern times, and that the germs of the ruin of states exist in those very causes which have produced their greatness. That power, riches, and leisure are essential to a great extension of philosophy and literature, and that they are likewise often the causes of vice and depravation, cannot, indeed, be denied; but a few facts, derived even from the history of the empires of antiquity, will distinctly show, that the influences of the arts and sciences, in great and wealthy states, tend rather to depress than to promote common luxury; and that those periods the most distinguished by elevation of moral character, by the social virtues, and by the higher feelings of the soul, were likewise the periods in which philosophy and letters were most cultivated, and in which the fine arts were ardently pursued. The most happy period of Grecian civilisa-

tion is that between the first Persian, and the second Peloponnesian, war. It was at the beginning of this period that literature and science made their first progrees in Greece; and at the time that they were studied with the greatest ardour, the patriotic spirit and the heroical virtue of the people were revealed in their full splendour. It was at the beginning of this period when Anaxagoras was instructing the youth of Athens in speculative philosophy; when Hippocrates was laying the foundations of medical science; when Democritus was pursuing the paths of experimental inquiry. It was at the same time that the minds of the inhabitants of Attica were kindling with the poetic feeling raised by the immortal genius of Homer. It was at the same time that they prosecuted their most active war of liberty against the Persians; that Miltiades and Themistocles led on their troops to conquest. It was at the same time that Leonidas and his 300 Spartans fell at Thermopylæ, martyrs in the cause of freedom, and glorying that they were permitted to die for their country. It was towards the close of this period that sculpture, painting, and the arts of life flourished in full vigour. It was at this time that the chisel of Phidias raised out of the rude marble forms of majesty and grace. It was at this time that the same dramatic poet, Sophocles — whose immortal compositions will ever continue as models of excellence — appeared as a warrior and conqueror at the head of armies; and that the same philosopher, who was called the wisest of men, endured all the hardships that the life of a common soldier can offer. And, perhaps, the character of the age can scarcely be better delineated than in one of the incidents in which he was the

actor. Alcibiades, his disciple, was wounded in the battle of Delium. Socrates carried him on his shoulders, defended him, and dared, at the same moment, to expose his life for his friend and his country.

"Traits of a very different character marked the later periods of the republics of Greece; and, at the era when they were about to resign their liberties to the power of Macedon, the sciences and arts no longer flourished in their ancient seats, but had passed into the country of the conqueror. At this time Aristotle was obliged to fly from Athens; and a law was passed to prevent any teacher of philosophy from opening a school in that city, which had before been the theatre of her glory. Luxury and sensuality only occupied the minds of the people; and no persons were distinguished by public approbation except such as gave great entertainments, or such as possessed fortunes which enabled them to gamble largely; and, as we are informed by Athenæus, the year before the invasion of Philip, the freedom of the city, (an honour which before had been bestowed only upon potentates, warriors, and philosophers) was given to two young men, whose only merit was that their father had been one of the best cooks in the commonwealth.

"The same principles might be illustrated by examples from many other nations. Rome affords as many instances, and of precisely the same kind as Greece. And at a later period, the elevation, progress, and the decline of the power of the Arabians depended upon similar causes.

"The only time at which this last people were truly great and happy, was at the time in which literature

and science were patronised by Almanor and his successors, the caliphs of Bagdad. At the moment that the desire of intellectual improvement disappeared, the savage and sensual spirit of the religion of Mahomet carried its followers on to ruin, even amidst the triumphs of conquest; and the progress of the crescent, at first marked by victory and desolation, soon finished in ignorance and debility. All experience, all analogy, decidedly proves that, unless power and riches are employed for increasing the sources of mental gratification, and for keeping alive the activity of the soul, their tendency must be evil; and all the elder nations, who have fallen from greatness, have offered before their ruin similar characters: wealth without science, improving manufactures, or commerce; the few the conquerors of the many; and great cities peopled only with soldiers, with rich men, with parasites, and slaves.

" The refinements of the useful or ornamental arts in modern times bear no relation to the luxuries of the civilised nations of antiquity; and, as they are at present pursued, they are amongst the first causes of the general improvement of society; for they not only promote individual comfort, but they afford constant objects for employment: they preserve the love of invention; they promote emulation, and the desire of excellence, amongst the labourers in the same department; and they tend to unite the different classes of society by ties of usefulness, of mutual dependence, and of mutual advantage.

" To the superficial observer, the attempt to extend the refinements of inventions beyond that state in which they are fitted for all the useful purposes of

life, may appear wholly unnecessary; but it should be remembered, that, in aiming at perfection in a manufacture, the workman is constantly improving himself; and in attempting to produce articles which are to sell at a high price, he makes a number much better than they would otherwise be, which are disposed of at a moderate rate. A finely polished knife, for instance, which costs a guinea, may not have a better edge than one which sells for a shilling only; but the cutler who has produced the expensive knife, from his accurate acquaintance with his art, gained from habit and laborious operation, is able to make the common knife better, and at a lower rate. A thousand cases of the same kind might be adduced. The elegant models of the Etruscan vases, produced by the ingenuity of the late excellent Mr. Wedgewood, may be said to have no immediate application to common uses; but yet, in consequence of their invention, a spirit of imitation and of emulation has operated upon every branch of the porcelain manufacture, and even the forms and composition of our common pitchers and common flower-pots have, in consequence, been improved.

" In certain departments of industry still greater advantages result from the constant attempts to attain the highest degrees of excellence. Examine agriculture. No person who understands the luxuries of the table will assert that a sheep rendered enormously fat in rich pasture, or on turnips, is better, or a greater luxury, than one that has grazed on the aromatic herbage of the Welch mountains; — but in the attempt to produce this well-fed animal, which, perhaps, gains the prize at Smithfield, a number of others have been improved to a less extent, and rendered,

in consequence, more adapted to common use. And the high price of well-fed cattle has awakened the feeling of emulation amongst farmers, in consequence of which the nature of the best breeds of cattle has been studied; the manner in which they can be most efficaciously nourished considered; and, from the extension of such inquiries, all the principles of farming have been more minutely investigated, and the art of cultivating land improved, and adorned with new discoveries. The principle is general: whenever manufactures or any productions of art become articles of general consumption, the higher and more expensive refinements of them are absolutely necessary, not merely for their improvement, but likewise to prevent their decline.

"All parts of the system of commerce are intimately connected. Honourably acquired wealth in such a country as that in which we have the happiness to live, — honourably acquired wealth, I say, produces credit, and from credit arises capital capable of an extent almost indefinite. Hence proceeds the division of labour; hence the invention of machinery; hence the circulation of wealth and power from one extremity of the empire to the other; and communicating, like the vital blood flowing through the vessels, to every part health and strength. Hence all the productions of the globe are made subservient to the uses of man; and nature arises subdued by artificial means, not impoverished or deformed, but enriched, and rendered more beautiful.

"The useful arts in modern times have attained an infinitely higher degree of perfection than in the most splendid eras of antiquity; and the improvements and extension of the sciences will admit of no parallel

instances. That light of knowledge, which was only dimly perceived by the ancients, which was obscured by the clouds of error and of prejudice, has appeared to us in all its purity and brightness; and whilst Nature, and the order established by the Author of Nature, have been to a great extent developed, the science of man has not been neglected. The works which awaken the imagination and exalt the feelings have preserved all their effect upon the mind. By means of experiment a new creation, as it were, of facts have appeared—of facts as much superior to mere speculations as things can be to words. Letters, the great instruments of thought, have assisted science, and science has given new objects and new forms for adorning and extending literature. All the different branches of knowledge have assisted each other, and, like different instruments of music, the sounds of which combine in harmony, they have all co-operated in enlightening the mind, in extending its enjoyments, and in exalting the state of social life.

"Though so magnificent a structure has been raised in science rapidly, and as if by a kind of enchantment, yet it is still unfinished, and new labours, and new efforts of ingenuity, are required both for ornamenting and extending it, and for preventing any of its parts from falling into decay. Knowledge is like a river, which, unless its springs are constantly supplied, soon becomes exhausted, and ceases to flow on, and to fertilise. The mind requires novelty even as a stimulus to exertion; and the philosopher who has made a discovery in natural science, or the author of a work of genius in art or in literature, is a benefactor, not only to the present generation, but likewise to future ages; for he gratifies that

faculty of enjoyment which is pure and intellectual, and which must be more exalted as society becomes more improved.

"Very few persons in the present day are disposed to reason against the advantages resulting from the higher refinements of science and philosophy, and the only argument that can be brought forward is one founded upon the doctrine of common utility. When a new fact, for instance, is ascertained in chemistry, or in electricity, the superficial observer is very apt to slight it, if it does not immediately admit of some application to the common wants of life. This, however, is very unfair; for all experience proves that the greatest and most important inventions which have arisen from scientific principles have never been ascertained till long after the principles themselves were developed; and so intimately connected are all the objects of human inquiry, and so much dependent upon the sensible properties of bodies, that it is scarcely possible that any great theoretical improvement can be made without being soon accompanied with practical advantages. A newly-discovered country ought not to be neglected, though it cannot be immediately brought into cultivation, because it does not immediately produce corn, and wine, and oil.

"But, independently of these considerations, all truths in nature, all inventions by which they can be developed, are worthy of our study, for their own sake, rather than with any idea of profit or interest. Whatever can enlarge the views of the mind, raise new sentiments of intellectual pleasure, or make us acquainted with new properties and powers in the substances surrounding us, is in the highest degree

worthy of the pursuit of a being whose noblest faculties are reason and the love of knowledge.

"All the discoveries, all the works of human genius, are of great importance to the community; but that their full effects may be produced, it is necessary that the public mind be prepared to enjoy them, and to estimate their advantages. The general diffusion of letters and philosophy is necessary to the progress of the higher inventions of the mind; for unless the labours of men of ingenuity meet with public support and approbation, they can never be actively pursued, and must soon languish and die. All minds require hope to animate them to exertion, and the desire of glory is one the most common to great and elevated understandings. The increase of general knowledge must uniformly produce the general patronage of letters and philosophy, and this is a most excellent and important end. Men of genius, in former times, have often languished in obscurity, not because their merits were neglected, but because they were not understood. This, however, can scarcely happen in the present day, in which all sources of useful information are laid open, and in which unparalleled exertions have been made in the higher classes of society to diffuse improvement, and to promote all objects of inquiry which can benefit or enlighten the public. There are other uses, still greater uses, resulting from the communication of general and popular science. By means of it vulgar errors and common prejudices are constantly diminished. It offers new topics for conversation, and new interests in life. In solitude, it affords subjects for contemplation, and for an active exercise of the understanding, and in cities, it assists the cause of religion and morality, by preventing the

increase of gross luxury and indulgence in vicious dissipation. Man is designed for an active being; and his spirit, ever restless, if not employed upon worthy and dignified objects, will often rather engage in mean and low pursuits than suffer the tedious and listless feelings connected with indolence; and knowledge is no less necessary in strengthening the mind, than in preserving the purity of the affections and the heart.

"Some few arguments are now and then brought forward against the efficacy of popular instruction. It is urged, that superficial and general knowledge often tends to produce pedantry, and that persons who are only imperfectly learned are sometimes vain and presumptuous. With regard to the charge of pedantry, it can only be applied to the half-taught in manners, as well as in science; and, in such a refined period as this in which we live, it is scarcely possible that such a folly can flourish. What is sometimes called pedantry, indeed, may depend upon the ignorance of the many, as compared with the knowledge of the few; but the moment the language of science becomes the common language of refined society, every feeling of this kind must cease; and till that event takes place, the person must be very, very deficient in common sense, who endeavours to astonish by a parade of knowledge; and who, being in possession of a light, chooses rather to employ it for dazzling the eyes of others, than to use it for his own guidance.

"That persons who are only *beginning* to attend to the principles of science often overrate their acquirements and abilities, cannot be denied; but this is a circumstance of very little importance, and seldom of much permanence. In every well-regulated mind false confidence cannot be of any long duration.

Vanity almost always carries with it a certain cure. Disappointment soon follows the ardent hopes of wild presumption, and, in a sound understanding, the conviction of having been once mistaken generally produces discretion and caution, which daily become more habitual, which direct the mind in its judgments, and which, when combined with feeling, become the foundation of a just and accurate taste.

"All human knowledge is necessarily imperfect; but the further it extends, the better are its effects. No efforts made for the attainment of truth ought to be slighted. Lofty ideas are often connected by man even with his weakness and follies: how much more ought they to arise from his strength and his wisdom! His powers are often wasted in attempts to obtain trifles, which vanish or cease to delight at the moment they are in his possession; and we ought always to rejoice when those powers are applied to objects which are permanent, and connected with true glory. Man is formed for pure enjoyments; his duties are high, his destination is lofty; and he must, then, be most accused of ignorance and folly when he grovels in the dust, having wings which can carry him to the skies."

After this Lecture on the advantages of knowledge, and the cultivation of the intellect generally, I find another, for which this is a suitable place, introductory to his course on the "Chemistry of Nature," written, as it is noted, on the 30th of January, 1807, to be delivered on the 31st. This was intended to recommend especially the study of chemistry as a philosophical pursuit to liberal minds; and to this end it is well fitted by the display of the vast extent

and resources of chemistry; how the most remarkable phenomena of the physical world are within the sphere of its power; and how it is impossible to understand any of the various changes which are perpetually taking place around us in nature, without reference to the principles of this science. He had then completed the "Electro-Chemical Researches," which were published in his Bakerian Lecture for 1806; and had the firmest confidence that the career of discovery was only commenced in this department of knowledge, and that other discoveries were about to be made of the most important kind, to which, even in imagination, he could see no limits.

"INTRODUCTORY LECTURE TO THE CHEMISTRY OF NATURE.

"Dependent upon the forms and beings of external nature for the gratification of our wants, and for many of our comforts and enjoyments, we habitually acquire from individual experience a certain degree of information concerning their operations and their changes.

"This information, however, is extremely imperfect. The most acute and penetrating genius, unassisted by scientific methods, wholly fails in its attempts to trace effects to their causes: and an acquaintance with the minute relations and properties of natural objects, and the laws by which they are governed, can be obtained by philosophical study only; by an inquiry into natural science, into that system of extensive knowledge which has been accumulated in different times, and collected from a variety of sources, by multiplied observations, labour, and ingenuity.

"Natural science is founded on minute critical views of the general order of events taking place upon our globe, corrected, enlarged, or exalted by experiments, in which the agents concerned are placed under new circumstances, and their diversified properties separately examined. The *body* of natural science, then, consists of *facts;* its governing spirit is analogy,—the relation or resemblance of facts by which its different parts are connected, arranged, and employed, either for popular use, or for new speculative improvements.

"The chemical phenomena of nature constitute the objects of one of the most extensive branches of the science. The parts of all known bodies are capable of new arrangements; and all the changes in their constitution, whether rapid or slow, whether the work of hours, of days, or of ages, whether grand or minute, are equally the subjects of chemistry. The study embraces a great number of principles and facts, various in their nature, importance, and applications. A general view of the order and plan of the course will, perhaps, not be considered as an improper introductory illustration. This view, from the multitude of objects which must be crowded together, will, I fear, be very tedious; but it is necessary, and, if you will attend to it, may remove some difficulties, and it may prevent disappointment; for it will explain how much of common and familiar philosophical detail will be introduced, the general arrangements to be adopted, and what new matter and new elucidations will be offered.

"The order of nature is immediately dependent upon the continual transmutations and changes of external objects. The variety of the forms of things, their unceasing modifications, but, for chemistry,

would be unintelligible enigmas. The diversities of matter, the causes of its mutations, are perhaps the first amongst the subjects of speculation that press themselves upon the inquisitive mind; and they will likewise be the first to occupy our consideration.

"The researches of modern chemistry, the methods of the experimental art, have demonstrated that all natural bodies consist of different arrangements or combinations of a few simple parts or elements, and it is on the knowledge of the invariable properties and agencies with which these elements are endowed that the whole of the demonstrative part of the science depends. Amidst their numerous alterations, the chemist is generally capable of arresting them, and of examining them in their pure forms, and in their different states of existence: whether as solids, as fluids, or as aëriform substances, they are almost equally within his power, equally capable of being investigated by experimental means. On this subject I shall enter only generally, illustrating it rather by striking examples than by minute details: common events even will afford a number of instances. Moisture, which falls from the atmosphere in rain, is again dissolved by it, or enters into the composition of animal or vegetable bodies, or mineral formations; but when chemically examined, it still retains the same constitution, the same permanent properties. The coal in our fires is converted by combustion into a peculiar species of air, which is dissolved by water, carried into the soil, and changed in the elaboratory of vegetable life; but the elementary matter may still be traced with precision — the same in weight, in quality, in essence.

" *Heat*, the greatest, the most universal, perhaps,

of natural agents, will next claim our attention. Some of the noblest of the works of modern chemical discovery are connected with this subject; and the same truths which led to the greatest extension of our mechanical powers ever invented, in the management and effects of steam, have likewise elucidated an immense number of natural phenomena, before perplexed and obscure. In this part of the course I shall detail the doctrines of Professor Black, and the later discoveries and facts of Dr. Herschel, Count Rumford, and Mr. Leslie, as far as they claim any relation to the general subject. On this point our views may be materially assisted by experiment; and I shall endeavour to offer such sensible illustrations, as may be clear and distinct. Natural appearances, however, and the great cycle of terrestrial changes, will afford a copious narrative of facts. It is on heat that the fluidity of water, the elasticity of air, and the form of the soil, depend. It penetrates every where, and is every where efficient. Terrible in its *partial* destructive and consuming agencies, it is admirable in its *general* beneficial and useful effects. The beauty and order of nature are connected with its operations; and the progress of vitality, as it were, follows the successions of periods and seasons, and the changes of temperature in the diurnal and annual motion of the earth and the sun.

" *Light*, much less powerful as a cause of chemical change, will occupy much less of our time. The experiments of the separation of its rays, and their different chemical effects in the pure forms, will afford some curious matter for discussion. The researches of Dr. Herschel have sufficiently shown the distinctness of light and heat. But as heat usually coexists

with light, it is not easy to determine clearly the operation of this last agent. It occasions, however, or at least influences, a great number of natural changes. Crystallisations, the alterations of colour of bodies, the health, and, ultimately, even the life, of vegetables, depend upon its agency; and, as M. Lavoisier has well observed, it is on the surface of the earth only, where the forms of matter are exposed to light, that organisation, spontaneous motion, and sensation exist.

"*Electricity* will offer a more extensive field of information and discussion. That power, the demonstration of which, as identical with lightning and the cause of thunder, was one of the greatest philosophical triumphs of the last century, there is every reason to believe, is not limited in its operation to the atmosphere, but is constantly producing the most important effects in the other great parts of our system. The galvanic phenomena, only lately identified as dependent upon the same principle, have afforded to us new and excellent instruments, and most powerful means of investigation, and have connected in a remarkable manner electricity and chemistry. The discoveries of Franklin, Volta, Galvani, and Walsh, and other philosophers in our own country, who have eminently enlightened the subject, will be successively examined.

"In this department of the inquiry I shall be able to offer some novel views, and various original experiments. It would be improper for me to avoid mentioning my own labours; but I feel full confidence that I do not risk the imputation of vanity. The observations that I have been able to make will at least show the very intimate relation that exists

between the electrical energies of bodies and their powers of chemical combination; and the processes will exhibit a variety of new methods of decomposition and analysis, which, I trust, will not be found wholly devoid of theoretical application and practical advantages.

"The apparatus of Volta, analogous to the organ of the torpedo, and the gymnotus electricus, produces, silently and slowly, the most astonishing changes. The appearances of fire and light, associated with all the early discoveries in electricity, and which rendered the facts popular, brilliant, and impressive, are far from being connected with its most important agencies. It is not by flashes, by explosions, and sparks, but by quiet, gradual, and almost unperceived operations, that it produces its greatest effects; and, generally diffused, like heat, it, perhaps, is equally active, equally important, in the economy of nature. After having closed the consideration of the active and etherial powers, as they may justly be called, which are continually operating upon gross and ponderable matter, the next subjects for our inquiry will be the common arrangements of bodies in the three great divisions of the globe—the atmosphere, the ocean, and the solid surface of the earth.

"*Air*, supposed in all the ancient systems of philosophy to be an uniform and immutable element, is now known to contain not merely different chemical compounds, but likewise different mechanical mixtures of various elementary substances. Its constitution will be experimentally demonstrated; both the early and the later researches will be examined; and it will be found, for the glory of our science, and our own country, that its composition was first accurately shown by a British philosopher still living; and that,

after twenty-five years of error and doubt, his estimations have been universally admitted and adopted, both abroad and at home. The subject of the nature, constitution, and agencies of the atmosphere will furnish ample sources both of experimental and theoretical elucidation. The action of one of the constituent parts of air upon inflammable bodies is the cause of the beautiful and important phenomena of combustion: it is the medium by which the solar light and heat are transmitted to us, and their powerful agencies are dependent upon a peculiar state of its constituent parts. Unequally heated by the action of the sun upon the surface of the earth, different strata of air are constantly changing their places, and currents are established, which, modified by the rotation of the globe, produce all the varying phenomena of the winds.

"The atmosphere, though the receptacle of all the elastic fluids formed or developed on the surface of the earth, is nevertheless uniform with regard to the proportions of its principal elements; and those parts of it which are absorbed by bodies, which are taken into the lungs of animals as an essential nourishment, are again supplied by a series of beautiful operations. In consequence of changes in the temperatures of different portions of air, a part of the water that they contain is often deposited in a state of minute division; and hence arise all the beautiful and varying appearances of clouds; hence snow and hail, and hence rain and dews, that supply the earth with vivifying moisture. All the particles of the atmosphere are active in forming combinations with water, and with substances contained in soils; and by means of its extensive and diversified operations the fertility of

the earth is preserved, and she is rendered a fruitful mother of living beings.

"The arrangements of the waters of the globe will follow in proper order, and their nature and changes will afford a variety of cases of chemical action.

"In the great extent of the ocean an important series of effects are constantly taking place. Though a number of substances are carried into it from the land, yet by chemical operations it is preserved in an uniform state, and its saline and aqueous parts duly mixed together. Warmed by the solar heat, it diffuses its pure moisture through the atmosphere; agitated by the winds and tides, its waves are combined with air, which, dissolved at the surface, passes even to the remotest depths, and becomes a principle of vitality to the beings inhabiting them.

"Our rivers and streams, which owe their remote origin to moisture carried by evaporation from the sea, undergo analogous changes; but, being in a constant state of motion, they are modified to a greater extent. Their composition is affected by the substances which constitute their beds; and their materials, after undergoing a variety of alterations, are either returned to the bosom of their parent ocean, or made subservient to the purposes of life in new forms.

"The solid surface of the earth will next be considered. The theatre of all the grand changes occurring in nature, it is in itself comparatively fixed, and comparatively immutable, and the substances composing it are, above all others, endowed with invariable qualities. This part of the course will include the pure and elementary geology, freed from all cosmogenical inquiries, from all hypothetical generalisations, whether the dreams of ancient times, or the

ingenious and beautiful visions of modern philosophers. On this subject I shall be able to introduce a number of original observations made upon the constitution of the strata of the earth, which will, perhaps, have a peculiar interest, as belonging principally to these islands; and they will be illustrated both by specimens of rocks, and by large coloured sketches.

"The soil, the decomposed exterior crust of the earth, consists of finely divided matter, daily in a state of change from the operation of common natural agents; and when its parts are consolidated by the recent agency of water, it is considered as alluvial, or the latest class of rock formations.

"The strata disposed in layers parallel to the horizon usually abound in the remains of shells, marine animals, and plants, of which very few classes are now existing: and these are the epizootic, or, as they are usually denominated, the secondary strata. Their origin is connected with an obscure period of time, when the present land was covered by the water, and they remain as monuments of a grand and awful catastrophe that has happened to our globe.

"The class of rocks composing the summits of the highest of our mountains, and extending to the remotest depths accessible to human observation, are crystallised masses, consisting of a few elementary materials, apparently rudely arranged, and yet bearing in their most imperfect parts characters by which they may be distinguished, and types marking their species. Free from any fragments, — containing no organic remains, they appear, at first view, as if exempt from the common law of decay, and from the operation of time; yet their external and superficial parts,

where fully exposed, undergo chemical alterations; and, by the general effect of the inequalities of the foundations of the surface, a number of important changes are constantly produced. Earth is supplied from the mountains to the plains and valleys; by means of mountains a greater inequality of temperature is produced; water is supplied to the low countries, and the course of the winds modified.

"In all this system, whether in its state of rest or of motion, the great end is the conservation of living nature. The laws of inorganic matter seem constantly active and efficient for no other purpose, and, amidst all the changes of the globe, *animation* rises unsubdued and supreme!

"The last branch of these lectures will concern chemical operations, as far as they are connected with the powers of living systems. On this subject, as yet, little has been effected; and the materials, though important, are few and slender. The skirt only of the veil which conceals these mysterious and sublime processes has been lifted up, and the grand view is as yet unknown.

"Of vegetable chemistry, which has lately occupied a particular course of lectures, I shall have little to say; I shall confine myself merely to general views of its relations to the great chemical economy of nature.

"The functions of animals will offer more extended objects of research. Digestion, nutrition, and, above all, respiration, will admit of various elucidations from the laws of chemistry; and, in whatever is known, a beautiful order, and an excellent adaptation of the means to the end will be found.

"Such is the outline which I shall endeavour to fill up. After having given so extensive a detail of the

objects to which the course will relate, it will be scarcely necessary for me to enter into any minute display of the importance or advantages of the study. You must have already felt and already weighed them; and it is far from my wish to attempt to seduce you to become partakers in a repast, which you may find rather coarse and homely fare, than a sumptuous and elegant entertainment. Some things, as I have said, will be new; but many will be old, or belong to the order of philosophical common-places. A few experiments will be upon a considerable scale, and connected with brilliant results; but a far greater number must inevitably be minute, will require attention to be seen and understood, and will be valuable only in consequence of their applications. The subject, likewise, I fear, will admit of few amusing details — nothing to awaken pleasantry — nothing to excite wit. There are no *anecdotes* of nature: these, indeed, belonged to the systems of the Greeks, and the nations of antiquity; but the philosophy of Bacon and Newton has fortunately excluded them from our schools. The history of things, and their faithful representations, will be the only sources of interest; and the love of nature and of truth are almost the only feelings that can be gratified by the pursuits of this part of experimental knowledge.

"In some respects, indeed, the chemistry of nature is superior to any other departments of the science. It is not much connected with laborious operations in crucibles; with the effects of mixture, the minute forms and combinations of artificial processes in phials, retorts, or alembics; but it is principally founded upon the observation of extensive and obvious changes. And its machinery is composed of

the great forms and elements of the external world, which are at once objects of vulgar admiration, of imitation in art, and of poetical description. Sunshine, winds, vapours, clouds, rivers, and cataracts are its prime agents; and the scenes of their operations, the diversified face of nature, the sky, the ocean, mountains, plains, and valleys.

"In another point of view, it may perhaps be said to offer a peculiar source of interest to active and energetic minds. It is one of the few branches of experimental philosophy capable, as our methods now apply, of very exalted improvements; and the new instruments in this science are capable of most extensive applications, and, in the hands of ingenious men, will probably lead to discoveries as important, or even more important, than those made by the early philosophers of modern times by the invention of the microscope and telescope, when new worlds of minute forms were developed by means of them upon the earth, and new grand worlds, and solar systems, discovered in the heavens. The methods of investigation have been ascertained, but, as yet, little used. We are, as it were, cultivators in a new country; the woods, as yet, have only been cleared from the coast, but we have not penetrated into the interior fertile savannahs, nor to the grand mountain districts.

"In general, the same arguments will apply to the study of this branch of science, and the various comprehensive departments of the great system of natural knowledge; and in this respect I can do little more than give a repetition of arguments, which I have already ventured to urge in favour of the popular and general study amongst the refined classes of society.

"The superiority of modern over ancient times seems to be in a great measure connected with the state of our physical knowledge, and the chemical and mechanical inventions and arts dependent upon its principles; for in many other respects the nations of antiquity were, perhaps, our superiors rather than our equals. Greece and Rome had their heroes and conquerors, who extended their power over the best part of the globe; their poets and orators, who produced the most harmonious combinations of language; their artists, who formed the most excellent representations of strength, of grace, and of beauty; but the mass of the people were plunged in ignorance and barbarism. The operations connected with physical science were unknown. Natural knowledge was neglected; and the men who called themselves philosophers, inattentive to experiment, chiefly pursued vain speculations, and, in attempting to predict concerning all things, discovered nothing: in following a shadow, they neglected the substance. The highest degree of distinction was soon attained. Hope was anticipated by enjoyment. No new object of inquiry arose out of intellectual pursuits. Literature and the fine arts arrived at a degree of perfection beyond which even ambition had nothing to desire; and when the turbulence of war had ceased, when the restlessness of conquest had passed away, they became only as roses, strewing the path that led to luxury and ruin.

"In these latter times, on the contrary, the dominion gained over nature by the processes and arts of experiment has contributed to the preservation of the mind in a continual state of activity. The exertions of unfettered genius have been constantly producing

new fields for investigation. Literature has been an instrument of science; science has given new ideas and new combinations to literature; and even the objects of the imitative arts have been extended in consequence of experimental research. The mind has been at once strengthened and refined, and the equilibrium between reason and feeling preserved. Men of science, instead of worshipping idols existing in their own imaginations, have examined with reverence and awe the substantial majesty of nature. Discovery has not visited them and disappeared again, like the flashes of lightning amidst the darkness of night; but it has slowly and quietly advanced, as the mild lustre of the morning promising a glorious day."

I shall give one Lecture more, almost entire, introductory to the course on Geology, which he delivered in 1811, and which was founded on an earlier one of 1805; when, as he himself says, the science of geology was in its feeble infancy; when no one had preceded him in this country in lecturing on the subject; not a single elementary book had been written on it; and when he had to collect his materials from various remote sources, and, from disjointed members, construct a body of geological knowledge:—

"INTRODUCTORY GEOLOGICAL LECTURE.

"So different are the exertions of the faculties of the mind, and so infinitely various the combinations of our ideas, that *the same objects* may be examined with the most opposite views, and considered under many diversified and beautiful relations.

"It is on this fact of our nature, so familiar to every understanding, that the great extent and progression of science and philosophy depend. Hence their division into various branches, and hence the distinctness and accuracy of the different species of knowledge.

"The planet that we inhabit may be considered, in its connection with the general system of the universe, as acted upon by gravitation, and revolving round the sun. It may be considered as the abode of organisation and life, covered with vegetables, and peopled with animals; or it may be studied as composed of different inorganic parts, variously arranged, and subservient to different uses.

"It is under the last point of view that it is the subject of *Geology*. This word is derived from the Greek language: it signifies *science of the earth;* but its acceptation is limited, and it is applied only to the branch of knowledge relating to the nature, position, and changes of the bodies that compose the *known* parts of the surface of the globe.

"The outlines of the science are plain and obvious, and they may be illustrated even by common observation from a superficial view of nature. I shall attempt a delineation of them, which I hope will be found an appropriate introduction to the study of the science, and I shall point out the order in which they will be considered in these lectures.

"The first impressions received from the exterior of the globe are those of diversity, variety, and beauty. Hills, vallies, and plains, appear covered with different soils, and affording different vegetables. Mountain chains are seen presenting irregular summits, bare or capped with snow, or emitting volcanic

fires; and their foundations form the beds of rivers, or the shores of lakes, seas, or the ocean.

"In different mountains and rocks, there are two remarkable distinctions of arrangement. Some are irregularly heaped together in large masses, or layers, which are divided almost perpendicularly to the surface. Others are arranged in bands, or strata, parallel, or very slightly inclined to the horizon.

"The first consist, for the most part, of crystalline stony matter; they contain few fragments, and exhibit few vestiges of a former order of things: these are called primary rocks.

"The second usually contain abundance of chemical deposits, water-worn stones, sand, and even clay, and they often abound in vegetable remains, and the exuviæ of marine animals: these are called the secondary rocks. Both these great orders contain dykes, or veins, which are more or less perpendicular; and which have been fissures, or chasms, filled with different substances, embracing a variety of metallic ores.

"The primary and secondary rocks; their transitions into, or relations to each other; and the different substances they contain, are the first and most important objects of study in geological science, and they will be the first to occupy our attention in this course of lectures.

"The variety, the shades of difference, seem almost infinite; yet their relations are capable of becoming the objects of distinct study. The rocks of different districts, where there is a considerable extent of surface, are generally found of the same species; similar varieties have similar associations in climates the most distant, and the chasms or veins that they in-

fold usually contain the same metals, and the same crystallised bodies.

"The arrangements of rocks and mountains in nature, and of the minerals they contain, are admirably adapted to the economy of things; and these arrangements will be pointed out and discussed. The metallic ores, so useful in the arts of life, which would be noxious if distributed over the surface of the globe, are concealed within its bosom, where they serve to awaken and employ human industry and ingenuity. The irregularities of the surface, so calculated to delight the eye by their sublimity or their beauty, are absolutely essential to the order of the system. They diversify the temperature of the earth; the cooling agency of the high lands is a cause of rain and vivifying dews; the water raised in vapour from the ocean is condensed on their summits, and flows in springs, and streams, and rivers, to produce vegetation, and multiply life in valleys and plains.

"After considering the existing order of things in the forms which, at the moment, appear permanent, the next step in the inquiry will be, the laws of their alterations. On this subject the human powers are necessarily limited; we have as yet penetrated to a small depth only below the surface; and there may be an interior mechanism in the centre, of which we have no knowledge. The effects of heat, light, air, and water, upon the surface, are almost the only circumstances which we are capable of accurately studying; and even with respect to these our sphere of observation is very small. The works of ages cannot be judged of, except very imperfectly, by their effects, in hours or days; the laws of Infinite

Wisdom cannot be fully estimated by finite intelligence; yet there is a glory in the effort, and delight and instruction in the result.

"The primary and secondary rocks, which form the known solid parts of the globe, undergo at their surfaces a continued series of changes; and the causes of their decomposition are the alterations of temperature to which they are exposed, assisted by the chemical and mechanical agency of water, and the attraction of their constituent parts for principles contained in the atmosphere. Firm and immutable at their bases, the parts of our mountains, wherever they are exposed to air and moisture, lose their durability and their stony texture, in consequence of chemical and electrical agencies, and become subservient to the production and renovation of soils. From the decomposition of a variety of rocks, and from the mixture of their elements by the agency of water, of streams and rivers, varieties of earths result, fitted for all the different modifications of vegetable life. In plains, in valleys, and on the low hills and mountains, they support plants and trees, subservient to the nourishment and shelter of the superior animals, and to the uses of man. On heights, where the larger plants are incapable of growing, in consequence of the intensity of the cold, or the force of the blast, grasses are still found, and vegetable life extends its empire, by means of mosses and lichens, to the limits of perpetual snow.

"When the effects for which decomposition seems principally to operate have been attained, the causes lose their energy, and the surface is in a great measure defended by vegetation, and by the vegetable

earth, from any new action of the elements, and novel matter even is accumulated upon it from water and air, which at first were the principles of its decay.

"By the degradation of surfaces of rocks, fertile slopes are formed, where before there were only barren precipices. Lakes are filled up, the lower parts of the beds of rivers are diminished, and a finely divided earth is transported, by the mechanical agency of water, from bleak or inaccessible mountains, to supply the waste of soil in cultivated valleys and plains.

"Amidst the changes and circulation of matter, a certain quantity of the solid materials of the land is carried into the sea; but in this circumstance, when fairly considered, there is no principle of general destruction, and there are a number of counterbalancing agencies. Low islands are forming, or constantly increasing, at the mouths of great rivers, from the opposing agencies of the tide and the stream; coral rocks are continually forming in the great extent of the ocean, and they are already the bases of many fertile islands in the Pacific; and subterraneous and submarine fires are active in extending land: so that the principle of change seems essential in all terrestrial nature; but, by an equilibrium of powers, by the coincidence of effects, the system continues the same; and the order by which the globe is preserved, fitted for the purposes of life, appears as fixed and unalterable as that which insures the reproduction and continuance of the tribes of living beings, its inhabitants.

"We are carried by anticipation from the present to the future, and the imagination is equally active with respect to the past. In considering the phenomena of geology, it is impossible to avoid conjectures concerning the former alterations of the globe. The

productions of the sea are found embedded in high mountains; the whole of the surface appeals to us in the intelligible language of the Roman poet, which may be thus translated:—

> ' Remains that to the waters owe their birth
> Occur in rocks beneath the solid earth;
> Where our rich fields their varied face display,
> Once in proud triumph flow'd the azure sea;
> And in the change of things, and lapse of time,
> The conquering waves have form'd another clime;
> And where another land its verdure spread
> Is now the moving ocean's tranquil bed.'

" But on what great causes have these wonderful changes depended, by what laws, or according to what principles, have they been produced? This inquiry is a most interesting, I may say a most sublime, part of geology. It generally occupies the first place in systematic works: I shall treat of it in the last place in these lectures, because it will always be a hypothetical investigation. It cannot be in any way made a series of facts — its productions must be probable analogies.

" The most striking and brilliant view of the subject is that which was developed in its first form by the genius of Hooke, and which has ripened into what is usually called the Plutonic theory. In this theory all the phenomena of geology are supposed the result of an uniform system, in which there has been no derangement, but one constant order. The land, it is said, is continually degrading and decomposing by the agency of water, and, in the course of cycles of ages, must be entirely destroyed. But there is an antagonist power of renovation —*fire*, which, acting beneath the bottom of the sea, is continually raising land, from which continents and islands result. Our

rocks are crystalised or consolidated, and must, say the advocates for this opinion, have been once fluid or soft; and fire is the only agent adequate to such an effect, which, acting under the pressure of the ocean, must produce results very different from those which it occasions in the free atmosphere.

"According to the Plutonic notion, all our rocks have been formerly the materials of another land, and the organic remains they contain are considered as so many proofs of this circumstance. In this system, decay and renovation are conceived to be perfectly balanced: water degrades; fire reproduces; and they are imagined to be opposed to each other, like the evil and good principles of the Persian mythology, Arhimanes and Ormuz, the destroying and creative genii.

"From what I read a few minutes ago, it is evident that, in referring to the actual changes now taking place upon the globe, we must admit the operation of causes similar to those adopted in the Plutonic hypothesis; but it is a matter of doubt and of discussion whether they must be admitted as universal.

"One great difficulty opposed to the igneous theory, was the source of heat. But this may be accounted for by supposing the interior of the globe composed of the metals of the earths, which the agency of air and water might cause to burn into rocks; and even the reproduction of these metals may be conceived to depend upon electrical polarities in the earth; and in this manner an harmonious order may be assumed: but though the idea is one which I have myself ventured to throw out, I cannot avoid saying that it rests on pure speculation. It does not command our assent,

nor has it for me that high degree of probability which necessarily induces conviction.

"The view which is particularly opposed to the Plutonic is the Neptunian, and it is sanctioned by the authority of Werner, Kirwan, and De Luc. In this hypothesis it is conceived that all rocks are depositions or crystallisations from a solution in an aqueous menstruum, and that the secondary rocks were the latest depositions, being formed after the ocean was peopled with living beings. No order is conceived corresponding to the existing order of things; the whole system is founded upon the solvent powers of water. — It is a speculation very remarkable for its simplicity.

"Besides the Plutonic hypothesis, which considers rocks as the result of an existing order, and the Neptunian, which regards them as products of a slow process of creation and deposition from a chaotic fluid, there are other views, in which the present state of things is supposed to have resulted from a great and extraordinary series of events, by which the ocean was carried over the land, and the secondary rocks deposited upon the primary ones. Leibnitz and Whiston refer this great revolution to the agency of a comet, by which the tides were raised above the mountains, and carried round the earth, and by which the water was heated so as to gain new solvent powers: and they connect this event with the sacred and profane history of early times.

"In examining these different views, I shall endeavour to discuss the evidences on which they rest, and to estimate the degree of probability of the different arguments brought forward to support them. On

such a subject doubt is not merely excusable, it is, in fact, salutary. It is only by reasoning upon the operations of chemistry that we can hope to gain any just theory of the formation of rocks; and chemistry is every day gaining new instruments, and exhibiting to us new substances and powers; and the perfection of this science cannot fail to enlarge our views of the grand operations of nature.

"The most active imagination must rest somewhere: there is some point in which even a circle must be begun; and all the evidences deduced from the face of nature would incline one to believe, that the beginning of the existing order of things cannot be placed further back than the period attributed to it in the sacred writings; and it is this order only which it is in our power accurately to study.

"In this order the two grand circumstances are,

"1st, That the secondary rocks have been materially altered by causes acting from above. Strata have been swept away, valleys opened, cliffs laid bare, and yet the parallelism of the parts preserved.

"2d, That the primary rocks have been deranged by causes acting from below; they are irregular, their layers disturbed and diversified, and there is no distinct parallelism.

"It seems absolutely necessary to introduce more than one system of causes for the changes that have taken place. Fire renders bodies fluid, but it increases the solvent powers of water to a wonderful extent; and all substances possessed of chemical action on each other have their energies exalted by heat. It has been too much the fashion in philosophy to refer operations and effects to single agencies; but

there are, in fact, in nature two grand species of relationships between phenomena: in one an infinite variety of effects is produced by a single cause; in the other a great variety of causes is subservient to one effect. Both are equally important, and equally worthy of being studied; though the last has been least attended to, as the inquiry is more laborious, and the results less attainable. Instances of it may, however, every where be found parallel to those in geology. A variety of rays co-operate to produce the simple sensation of pure light; the numerous gravitating agencies of the planets and their satellites upon each other, and upon the sun, produce the simple effect of regular, harmonious, and invariable revolutions; the functions of animal bodies are supported by various nourishment, and by various sets of organs; and almost all the principles of matter, in their various combinations, are made essential to the existence and the pleasures of one being.

" In these things there is the nicest adaptation, an order calculated to awaken the strongest admiration. We ought never to judge of nature by the generalisations which exist in our own fancy. We are compelled to seek for simplicity on account of the weakness of our own powers. We are incapable of giving perfection and utility to complicated machines; and we are generally most impressed by that which approaches nearest to, and which most resembles, the best of our own productions. But man is merely the imitator, the servant, and interpreter, of nature: he labours in vain when he attempts to reason concerning the ultimate tendency of her works from that of his own. He is the slave of time: her operations are

in eternity, and high faculties are required to catch even a glimpse of the wise and wonderful laws by which they are governed.

"With the critical examination of the speculations and hypotheses on geology I shall conclude the course. I shall spare no labour; I shall employ all my feeble powers to make the subjects of it intelligible and useful; but lectures, even in their best and most popular form, even when they most awaken interest and arrest the attention, are wholly inadequate to fix in the mind the principles and basis of science. They may sometimes, indeed, in this case excite the uninformed to inquiry, and communicate general views; but they can be subservient to useful and extensive knowledge only when assisted by previous or collateral study of the subject to which they relate. It is for this reason that I urge on those of my audience to whom the science of geology is yet new, and who may really wish to become acquainted with it as students, the necessity of acquiring particular information by the examination of specimens, and by a course of reading.

"It is not necessary in the study of mineral bodies, in a geological point of view, to enter at once upon the consideration of the whole extent of the fossil productions of the earth. The principal rocks, which form the great foundations of the surface, are comparatively few in number, and may be very easily procured, and at an inconsiderable expense. The large sums of money which are often laid out in cabinets are usually devoted to the collection of rare and uncommon minerals; but these substances, though greatly interesting to the mineralogist and chemist,

are comparatively of little importance to the geologist, whose object is to study the usual productions and great facts of nature, rather than her accidental combinations and curious irregularities.

"The knowledge of the external properties of the common rocks, considered as fragments, is a necessary introduction to the study of the earth. But it must be always remembered, that mineralogy ought merely to be a preparation for geology, and considered merely as affording the characters by which its mysteries are deciphered; and that it is in the great arrangements of nature, and not in the details of the museum, that the facts and the foundations of the science must be sought for and examined.

"The study of the natural arrangements of rocks may, at first view, appear a very difficult and extensive labour, and to some persons an impracticable one; but to gain a general acquaintance with the subject it is not necessary to examine a great variety of districts, or a great extent of country. Our own island contains all the important species of strata, and that often in a very small compass, and in places which are easily accessible, and in which the arrangement is distinct. In Cornwall alone almost all the same geological formations as those found in the Alps, in Saxony, and in Siberia occur, and in the northern counties and western coast of Scotland the most interesting varieties of secondary and primary rocks may be found in a space of a few square miles in extent, and even at a smaller distance within a hundred miles of the metropolis. In Leicestershire there is a similar arrangement; and in a journey of a single day the peaks of granite of Mount Sorrel, the secondary rocks of Chawood Forest, and

the coal strata and their formations, may all be easily attained.

"In studying the natural appearances of rocks, much various information and many valuable hints may be derived from the examination of the descriptive writings of geological travellers; and there are many excellent works of this kind, developing correct views, and combining amusement with instruction. As a book most relating to the geology of our own country, I can with pleasure recommend the mineralogy of the Scottish islands by Professor Jameson. His descriptions are executed with correctness and address. I am able to bear testimony to the accuracy of many of his statements; and, whenever he has studied minutely or with labour, he is always ingenious and profound. Amongst the works which relate to foreign countries, it is unnecessary to dwell upon those of Humboldt; they have been recently brought forward in our most popular journals, and their merits ably displayed. The publications of Dolomieu, likewise, occupy a distinguished rank. This celebrated man was possessed of the true love of geology, and was guided in his researches by the most philosophical spirit. His writings, particularly those on the Lipari Islands, are distinguished not merely by accuracy of description, but likewise by a peculiar justness of thought and happiness of deduction. He is not a rapid traveller, who has merely sketched the outlines of objects; but he has studied them deeply, and examined their minute parts, their bearings and relations; and his pictures are equally valuable for their accuracy and their strength.

"Of a kindred character are the descriptions of M. de Saussure. Educated amidst the magnificent

scenery of the Alps, this illustrious person felt in his earliest days the warmest admiration of the study, and his whole life was more or less devoted to it. Possessing from nature a penetrating genius, he assisted its efforts by all the refinements and resources of science. In his researches he spared no labour, and yielded nothing to the common sentiment of self-love. A constant inhabitant of the mountains, he has exceeded all other writers in his descriptions of them. His delineations are equally vivid and correct, and, as far as mere language is capable, they awaken pictures in the mind. De Saussure has presented the rare instance of a powerful imagination associated with the coolest judgment; of the brilliancy of ideas and feelings of the poet, connected with the minute research and deep sagacity of the philosopher.

"In speculative geology, the essays of Mr. Kirwan offer an extended view of the Neptunian hypothesis; and this excellent and learned philosopher has employed all his talent to support what he conceives an orthodox system of the earth, and to overturn the Plutonic heresy. M. de Luc has lately published a work of a kindred character, which demonstrates equally the vigour of his mind and the powers of his body. The ardour of this veteran in science for the pursuit of knowledge seems to increase with his age. I cannot always agree with him in opinion; but I admire the spirit with which he pursues his subject, and the unsubdued energies of his imagination.

"The best view of the Plutonic theory in existence is owing to Professor Playfair, who has given to the ideas of Dr. Hutton, the ingenious founder of the doctrine, a new, a more philosophical, and a beautiful form. Dr. Hutton's system, as delivered in his ori-

ginal work, though marked by grandeur of view, and felicity of induction, and copiousness of fact, is perplexed and obscure in detail: the arrangement is unhappy, and but little calculated to facilitate the knowledge of the subject. In Mr. Playfair's hands, which have sometimes altered, and sometimes created, the theory, it loses its character of a confused effort of gigantic but ill-directed power, and becomes impressive from its simplicity, and seductive from its elegance; and is rich in instances of noble philosophical eloquence.

"From what has been said of the nature and methods of the study of geology, it is evident that the accurate pursuit of it must occupy a certain portion of time, and demand some labour and attention; and a fair question may be asked, What are its practical uses? What advantages are likely to arise from it? What interests will it promote? On this point I might undoubtedly shelter myself under the proposition, that "all knowledge is highly beneficial;" that whatever can awaken intellectual pleasure, or convey more exalted views of nature, or of the human talents, is truly worthy of our cultivation, and fitted for our faculties. But, independent of such considerations, regarded merely as a profitable and useful science, I may fairly say that geology is exceedingly worthy of being cultivated; and a few details will be sufficient to prove that the information to be derived from it is often applicable to important purposes, and may, in a number of instances, be made subservient to the wants of life.

"Fixed upon the earth, and dependent for our support and existence upon the various objects surrounding us, many of our necessities are supplied, and some of our highest comforts produced, by the application of substances found in the mineral kingdom.

"The soils from which our vegetable nourishment is raised, the stones of which our habitations are formed, the fuel we employ for so many purposes, and the metals so absolutely essential to civilised man, are all objects of geology; and as this science treats of their nature, arrangement, and association, it is evidently the most capable of affording useful discoveries with regard to their localities, occurrence, and readiest application. I have already mentioned that there is an order in the position of rocks, by which certain species are almost always found accompanying each other, and occupying the same district. In a mountainous country, for instance, if a rock of this nature occurred which is *serpentine*, we might be almost certain that this substance, which is *soap-rock*, would be somewhere found in it, and that this fossil, which is micaceous schist, would not be far distant. But in such a position it would be in vain to search for shell, limestone, or coal. Again, where soft shell limestone occurs, there is a strong presumption that soft black shale or loose sandstone will be found in some contiguous spot; and in such a country, there is little doubt that, at some depth, or in some direction, fossil coal would be discovered.

"These circumstances are fundamental facts of the science, and the ready application of them will be immediately evident. The person who is digging for pit-coal, if he meets beneath the soil serpentine, or micaceous or granite-rock, if acquainted with the arrangement and nature of strata, will be immediately instructed to give over his labour, and spare useless expense. But should he find sandstone,—a substance which, to an uninstructed eye, ap-

pears of much the same nature as granite, — it affords him some encouragement to proceed in his researches; and a yellow or red ferruginous sandstone, or a fine-grained white sandstone, or soft slate, bearing impressions of vegetable leaves, would offer very strong indications of the substance sought for; for these strata are generally immediately incumbent on coal. Similar reasonings may be applied to metallic veins. The metals seldom or never occur in rocks of serpentine, of sienite, or soft coaly schist, nor in sandstone, nor in basalt; but they may be looked for in soft granite, in hard schist, and in hard shell limestone. And if in granite or schist a vein of white stone is found running in a direction from east to west, there is much probability that in some part of its depth it may afford useful metal. And if veins of spar occur in rocks, partly hollow, and partly filled with a yellow substance of this kind, which, in Cornwall, is called Gossan, it may be almost concluded that such veins will be productive; and the larger the quantity of Gossan, the better the indication. Some very great losses and failures have often taken place in mining from ignorance in the directors of the common facts of geology. I shall mention a remarkable instance that took place in Somersetshire. Some miners from Cornwall were employed in working a rich copper-vein, near Nether Stowey. At a certain depth, the vein was crossed by a dike of stone. The miners cut in their accustomed direction, expecting immediately to reach the vein; but their efforts were wholly unsuccessful, and it was not till after some weeks, and much expenditure of money and labour, that the object was attained. The reason of their failure was, that the arrange-

ment of dikes in the primary county of Cornwall, and in the secondary county of Somersetshire, is very different. In the one, the vein cut through almost always appears shifted; and in the other it maintains its perpendicular direction. And the mere knowledge of this fact, which is almost general for the different districts, would have ensured the success of the operation.

"A number of instances of the same kind might be adduced. And the science is equally applicable in a number of other arts and professions. It ought to be particularly studied by the engineer who is employed in the construction of canals, or docks, or fortifications, as certain strata, exceedingly hard, often alternate with others that are very soft and easily cut through; and by a knowledge of their different positions and relations much unnecessary labour and expense may be often avoided.

"The drainer, in order to make his operations successful, ought to be minutely acquainted with the arrangement of the rocks in the district from which the springs arise, which it is his business to divert; and he ought to pay particular attention to the nature and position of *dikes;* for they often intersect soft strata, and stop the course of the water, and render all his operations useless till they are discovered and penetrated.

"The farmer and the improver of land, even, may often derive from geology very useful instruction with regard to the position of limestone, marl, and clays, their appearance, and the nearest places whence they may be procured. And, lastly, even the architect may often benefit by this science. Of the strata which afford stones employed in building, some

parts are much more liable to decay than others, and the external character affords the indication. Many rocks, exceedingly beautiful and tempting to the eye, and easily cut through, are often very liable to decomposition, — are easily destroyed by common natural agents, and their relations to permanency can only be known by scientific observation. I can mention two remarkable instances in which decomposing stones have been unfortunately employed in the construction of considerable edifices, which, in consequence, are most rapidly falling into decay. The one is Chester cathedral, which is constructed of ferruginous sandstone; and, by the action of water and air, all the exterior ornaments, and nearly a half of the surface of this venerable structure are destroyed. The other is the library of Trinity College, Dublin, which must have been a most beautiful building, but which, from decomposition, is rapidly losing all its elegance of architecture. And the circumstance is the more singular, as the principal rocks in the vicinity are beautiful and permanent granites; and, by some unfortunate circumstance, the materials selected for this edifice must have been brought from some distance, and probably at a great expense.

" It will be unnecessary to pursue these statements to any greater extent. Sufficient has, I trust, been said to prove that the science may be of national as well as of individual advantage,—and, at least, to establish its utility. It is far from my wish to endeavour to exalt geology to a higher rank than it ought to occupy, or to attempt to raise it unfairly above the other branches of physical knowledge; but I should be unjust to my subject were I not to state some

of the peculiar advantages which it possesses as a science of contemplation, and as a series of important truths, unfolding some of the most beautiful and important parts of the economy of nature.

"Of all material objects that can employ our attention, those that are nearest to us ought to excite the warmest and most immediate interest; and, after man and animated nature, no subject of physical inquiry bears a more distinct relation to us than the place of our abode — the earth, to which we are necessarily attached, and the mechanism of which is intimately connected with our powers, our enjoyments, and even our existence. The more general study of the science, and the constitution of the globe, affords some very beautiful and sublime views, which could never be gained from the common observation of external nature. It explains the importance of the variety and irregularities which it exhibits; and demonstrates that no parts are useless; and that the causes which apparently produce destruction and disorder are, in fact, in the general series, connected with the renovation and support of the system. If the interest of this species of knowledge is considerable, the *facility* of acquiring it ought, at least, to be a motive why it should be pursued. It requires no laborious or continued investigation; no expensive or complicated apparatus; no minute processes upon the unknown properties of matter. It demands only an inquiring understanding, an acquaintance with certain simple elements of knowledge, and a mind alive to the facts which are almost every where presented in nature.

"Geology is yet in an infant state. The great arrangements only are known; and whoever furnishes

to it new histories of facts becomes an improver of the science. The ease with which discoveries are made ought, undoubtedly, to fix the attention of active spirits. In this department of knowledge there are fields of investigation yet unexplored, rich in fact and theory, and the subject is one equally fitted for an exertion of the memory, the reason, and the imagination.

"The person who is attached to geological inquiries can scarcely ever want objects of employment and of interest. The ground on which he treads; the country which surrounds him; and even the rocks and stones, removed from their natural positions by art, are all capable of affording him some degree of amusement. And every new mine and quarry that is opened; every new surface of the earth that is laid bare; and every new country that is discovered, opens novel sources of information. In travelling he is interested in a pursuit which must constantly preserve the mind awake to the scenes presented to it. And the beauty, the majesty, the sublimity of the great forms of nature must necessarily be enhanced by the contemplation of their order, their mutual dependance, their connection as a whole. The imagery of a mountain country, which is the very theatre of the science, is in almost all cases highly impressive and delightful; but a new and a nobler species of enjoyment arises in the mind when the arrangement in it, its uses and its subserviency to life, are considered. To the geological inquirer, every mountain chain offers decided proofs of the great alterations that the globe has undergone. The most sublime speculations are awakened; the mind is carried into past ages; new

forms of existence are presented to it, and a boundless inquiry; the destruction of a former order of things, and a system arranged with harmony, filled with beauty and life, formed from its elements, and established on its ruins."

In prosecution of the plan proposed, I shall now make some extracts from his lectures in illustration of his powers as a lecturer, addressing a mixed audience of students and philosophers, of men and women of rank and fashion.

The following observations occur in an introductory lecture to a course on Electro-Chemical Science, which he delivered in the theatre of the Royal Institution in 1809, when a fund had been formed by subscription to construct a great voltaic battery of 2000 double plates, which was soon afterwards completed. An allusion to this leads him to remark on the public aid which experimental science requires; on the necessity of expensive apparatus beyond the attainment of most private individuals, both for purposes of research and demonstration; and on the vast advantages derived from funds thus expended, both in relation to the amusement and improvement of the mind, and the augmentation of the resources of a country. I shall give the whole of his observations on this important subject: though delivered on a particular occasion and time, they are of very general application, and may be always useful in exciting a scientific spirit and taste, without which science may be *patronised*, but never can be honoured and flourish:—

"In a former course of lectures, I adverted to the

circumstances which led to the proposals for constructing the new apparatus. I cannot avoid referring to them a second time; my inclination, my feelings, my duty render this necessary.

"In a great country like this, it was to be expected that a fund could not long be wanting for pursuing or perfecting any great scientific object. But the promptitude with which the subscription filled was so great, as to leave no opportunity to many zealous patrons of science for showing their liberality. The munificence of a few individuals has afforded means more ample and magnificent that those furnished by the government of a rival nation; and I believe we have preceded them in the application of the means. In this kind of emulation, our superiority, I trust, will never be lost; and I trust that the activity belonging to our sciences will always flow from the voluntary efforts of individuals, from whom the support will be an honour — to whom it will be honourable.

"In commenting upon the noble spirit by which this object has been effected, I trust the general state of this institution will be a reason why I should press still further the use and the necessity of patronising and promoting the objects of establishments connected with the progress of discovery, and the diffusion of experimental knowledge. This department of inquiry demands an apparatus which it is in the power of few individuals to provide. It is connected with considerable expense; and, though it may produce great public benefits, cannot, when carried on in the true spirit of philosophy, be a source of private gain.

"Without facilities for pursuing his object, the greatest genius in experimental research may live

and die useless and unknown. Talents of this kind cannot, like talents for literature and the fine arts, call forth attention and respect. They can neither give popularity to the names of patrons, nor ornament their houses. They are limited in their effects, which are directed towards the immutable interests of society. They cannot be made subservient to fashion or caprice; they must for ever be attached to truth, and belong to nature. If we merely consider *instruction* in physical science, this even requires an expensive apparatus to be efficient; for without proper ocular demonstrations, all lectures must be unavailing, — things rather than words should be made the objects of study. A certain knowledge of the beings and substances surrounding us must be felt as a want by every cultivated mind. It is a want which no activity of thought, no books, no course of reading or conversation, can supply. That a spirit for promoting experimental science is not wanting in the country, is proved by the statement which I have just made, by the foundation in which I have the honour of addressing you, and by the number of institutions rising in different parts of the metropolis and in the provinces. But it is clear that this laudable spirit may produce little effect from want of a just direction. To divide and to separate the sources of scientific interest, is to destroy all their just effect. To attempt, with insufficient means, to support philosophy, is merely to humiliate her and render her an object of derision. Those who establish foundations for teaching the sciences ought, at least, to understand their dignity. To connect pecuniary speculation, or commercial advantages, with schemes for promoting the progress of knowledge, is to take crops

without employing manure; is to create sterility, and destroy improvement. A scientific institution ought no more to be made an object of profit than an hospital, or a charitable establishment. Intellectual wants are at least as worthy of support as corporeal wants, and they ought to be provided for with the same feeling of nobleness and liberality. The language expected by the members of a scientific body from the directors ought not to be, 'We have increased your property, we have raised the value of your shares.' It ought rather to be, 'We have endeavoured to apply your funds to useful purposes, to promote the diffusion of science, to encourage discovery, and to exalt the scientific glory of your country.'

"What this institution has done, it would ill become a person in my place to detail; but that it has tended to the progress of knowledge and invention, will not, I believe, be questioned. Compare the expenditure with the advantages. It would not support the least of your public amusements; and the income of an establishment, which, in its effects, may be said to be national, is derived from annual subscriptions scarcely greater than those which a learned professor of Edinburgh obtains from a single class.

"With more ample support, more, undoubtedly, would be effected. With a devotion to the experimental sciences and arts, nothing but good could result from an extension of the undertaking: and it is no mean object to the country, that the first attempt of this kind should succeed.

"The progression of physical science is much more connected with your prosperity than is usually ima-

gined. You owe to experimental philosophy some of the most important and peculiar of your advantages. It is not by foreign conquests chiefly that you are become great, but by a conquest of nature in your own country. It is not so much by colonisation that you have attained your pre-eminence or wealth, but by the cultivation of the riches of your own soil. Why, at this moment, are you able to supply the world with a thousand articles of iron and steel necessary for the purposes of life? It is by arts derived from chemistry and mechanics, and founded purely upon experiments. Why is the steam-engine now carrying on operations which formerly employed, in painful and humiliating labour, thousands of our robust peasantry, who are now more nobly or more usefully serving their country either with the sword or with the plough? It was in consequence of experiments upon the nature of heat and pure physical investigations.

"In every part of the world manufactures made from the mere clay and pebbles of your soil may be found; and to what is this owing? To chemical arts and experiments. You have excelled all other people in the products of industry. But why? because you have assisted industry by science. Do not regard as indifferent what is your true and your greatest glory. Except in these respects, and in the light of a pure system of faith, in what are you superior to Athens or to Rome? Do you carry away from them the palm in literature and the fine arts? Do you not rather glory, and justly too, in being, in these respects, their imitators? Is it not demonstrated by the nature of your system of public education, and by your popular amusements? In what, then, are you

their superiors? In every thing connected with physical science; with the experimental arts. These are your characteristics. Do not neglect them. You have a Newton, who is the glory, not only of your own country, but of the human race. You have a Bacon, whose precepts may still be attended to with advantage. Shall Englishmen slumber in that path which these great men have opened, and be overtaken by their neighbours? Say, rather, that all assistance shall be given to their efforts; that they shall be attended to, encouraged, and supported."

The following extract in praise of experimental philosophy, and in one of its noblest relations, — its influence on the spirit of the age, and its tendency to strengthen rational freedom, and preserve a people from a brutal or irrational despotism, — is from a lecture on electrical science delivered, in May 1808 or 1809, when the subjugation of Europe was threatened by the military power of France: —

"In congratulating you on the present era of philosophical discovery, and on the dawn of a new science now opening upon us, I cannot conclude without adverting to what, in these peculiar times, appears to me a deep and interesting truth.

"The scientific glory of a country may be considered, in some measure, as an indication of its innate strength. The exaltation of reason must necessarily be connected with the exaltation of the other noble faculties of the mind; and there is one spirit of enterprise, vigour, and conquest, in science, arts, and arms.

"Science for its progression requires patronage, — but it must be a patronage bestowed, a patronage received, with dignity. It must be preserved independent. It can bear no fetters, not even fetters of

gold, and least of all those fetters in which ignorance or selfishness may attempt to shackle it.

"And there is no country which ought so much to glory in its progress, which is so much interested in its success, as this happy island. Science has been a prime cause of creating for us the inexhaustible wealth of manufactures, and it is by science that it must be preserved and extended. We are interested as a commercial people, — we are interested as a free people. The age of glory of a nation is likewise the age of its security. The same dignified feeling, which urges men to endeavour to gain a dominion over nature, will preserve them from the humiliation of slavery. Natural, and moral, and religious knowledge, are of one family; and happy is that country, and great its strength, where they dwell together in union."

The fitness of science to improve the female character is forcibly described in an introductory lecture, which he delivered in Dublin, in the theatre of the Dublin Society, in 1811: —

"In this room, I am sure, I need not enter into any elaborate arguments in favour of a certain acquaintance with the philosophy of nature in the system of improvement of the female mind. The same reasoning would, I conceive, apply in this case as to the study of the mathematics as a part of the education of the other sex. By accustoming the mind to strict reasoning, and minute observation as to matters of fact, the judgment is strengthened, and rendered more acute and distinct in its application to common affairs. Unhealthy sensibilities are destroyed, and the imagination refined and exalted. It has been too much the custom to endeavour to attach ridicule to

the literary and scientific acquisitions of women. The fashionable education is principally directed to those accomplishments which please only in that season of youth which in itself is full of fascinations; whilst it neglects the more solid endowments, which give a dignity and a charm to the advanced periods of life, and which, independent of external advantages, are exalted and rendered delightful by time. In a very popular work, Milton is quoted against the literary and scientific acquisitions of women; but the instance is an unhappy one; for this great man, most illustrious as a poet, unfortunately was not distinguished either for his respect, his attention, or his attachment to the softer sex; and yet, notwithstanding this, he has made the chief pleasure of the primeval paradise to consist in the study and admiration of the wonders of nature, as if conscious of their fitness for the best condition of our being. The standard of the consideration and importance of females in society is, I believe, likewise the standard of civilisation. The leisure of the higher classes is so great, their influence so strong, that it is almost their duty to endeavour to awaken and keep alive the love of improvement. It is only ignorance or selfishness which can wish to prevent the diffusion of knowledge. It is the grand privilege of human nature; it is the lamp which guides our steps amidst the obscurity of things, which preserves the mind awake to its just interests, carrying it from transient and trifling objects to those which are permanent and useful; affording a noble employment in youth, a delightful consolation in age; teaching that in all things there is order, and harmony, and wisdom; exalting the sen-

sual into the intellectual, and the intellectual into the moral and religious being."

In a geological lecture, after alluding to the durability of granite, and its fitness in consequence for public buildings and monuments, he makes the following appeal in favour of them: —

"In all cases when great public monuments are to be erected this is the stone that should be employed. In touching upon this subject, I cannot avoid expressing a deep regret that we have so few of these memorials in this great country. Yet our materials are copious. Our harvests of glory are as rich, nay, even more abundant, than those of the great elder nations. Why should the spirit be wanting by which they are to be gathered in, and made permanent? We have had philosophers who are the glory of the whole human race; heroes and statesmen, who are the rivals of the illustrious of Athens and of Rome: yet this metropolis offers no durable tribute of respect, either to our science, or to our naval or military glory; and in a thousand years, though there may be a new and more magnificent city on the banks of the Thames, yet there will scarcely be a wall of what is now beheld standing; — nothing to speak to posterity of what the people of Britain were in these memorable times — in philosophy, the guides, — in literature, the instructors, — and in politics, the assertors of the independence of Europe. Nor would such works be devoid of immediate utility, and beneficial effect. A few columns raised to the illustrious dead, — a few national laboratories or museums devoted to the memory of great men, and to the use of students, would rise as land-marks of fame, would continually excite

to excellence. No motive for exertion is so strong as that founded upon the sympathy of the good and the wise; no reward so sweet as that of being held up to public admiration as a benefactor of the species; no glory so pure, so calculated to awaken great minds, as that of immortality."

These few extracts may suffice as examples of the appeals, which he occasionally made to the feelings of his audience, in favour of the great interests of science, and the advantages attending its cultivation, which he took a particular pleasure in advocating.

The next extracts I shall make will be in relation to the doctrines of science, and the methods of research and discovery, with which I shall intermix some of his views relating to the influence of science on the minds of its cultivators, and the liberal manner in which it ought to be pursued.

The following remarks may serve as introductory. They are contained in some very early lectures on the "History of Natural Science," which, I believe, he never delivered, and of which fragments only are remaining: —

"In all cases in science, it is our business to analyse every principle, and to ascertain to what expressions of facts it relates, or to what simpler laws it may be referred. It is our duty to separate propositions from human passions, and to reason on them as mere representations of things; and to employ no terms that are either perplexed, or doubtful, or uncommon. The same processes of thought ever will apply in common life as in science. Experience must be our guide; experience, or moral feeling, founded on accurate and distinct knowledge. Words alone must never be suffered to satisfy or fill the mind, and

their relations to facts must be ascertained, before they can be considered either of importance or of use. The imagination must be subjected to the judgment, or rather they must mutually operate, and assist, and correct, each other. We may be always safely entertained by wit, — we may be always safely delighted by eloquence, — for they are the life and organs of the mind; but never let us consider wit as argument, or eloquence as truth, till we have coolly examined them by the test of right reason, for this is the only certain guide of opinion; a principle the same in all ages, and in all nations, independent of fashion or caprice — unchanging, immortal."

In an introductory lecture for 1811, on electro-chemical science, there is a very happy and lucid exposition of the modern manner of prosecuting science, and which, in his own researches, he always employed. The first part is to be found in the introduction which he prefixed to his Elements of Chemical Philosophy.

"The foundations of electro-chemical philosophy, like those of every other department of natural science, are observation, experiment, and analogy. By observation, facts are distinctly and minutely impressed in the mind; by analogy, similar facts are connected; by experiment, new facts are discovered; and, in the progression of knowledge, observation, guided by analogy, leads to experiment, and *analogy*, confirmed by *experiment*, becomes *scientific truth*. To the philosophical mind these ideas are familiar, but to the student an illustration may not be without advantage. Whoever considers with attention the slender green vegetable filaments (conferva rivularis), which in the summer exist in almost all streams,

lakes, and pools, under the different circumstances of shade and sunshine, will discover globules of air upon the filaments exposed under water to the sun, but no air on the filaments that are shaded. He will find that the effect is owing to the presence of light. This is an *observation*, but it gives no information respecting the nature of the air. Let a wine glass filled with water be inverted over the confervæ; the air will collect in the upper part of the glass, and when the glass is filled with air, it may be closed with the hand, placed in its usual position, and an inflamed taper introduced into it; the taper will burn with more brilliancy than in the atmosphere. This is an *experiment*. If the phenomena are reasoned upon, and the question is put, Whether all vegetables of this kind, in fresh or in salt water, do not produce such air, under like circumstances, the inquirer is guided by *analogy*; and when this is determined to be the case by new trials, *a general scientific truth* is established, that all confervæ in the sunshine produce a species of air that supports flame in a superior degree; which has been shown to be the case by various minute observations. And the general scientific truth admits of numerous applications to the economy of nature; such as the deterioration or renovation of the atmosphere, and the uses of even the humblest forms of vegetables in the general system of things. These principles of research, and combinations of methods, have been little understood, except in late times, and almost the whole of the great fabric of modern science has been raised upon them. A few important discoveries, indeed, have been owing to *accident*, but their application and connections have entirely depended upon experimental researches,

guided by just analogy. It is by experiment that different species of matter have been made to act upon each other, their relations determined, and their hidden properties discovered; and that facts have arisen from the workshops of the artisan, or from the furnaces of the alchemist, to become parts of an extensive and profound science. Experiment may not unaptly be compared to the chain in mythological romance, which binds down the Proteus of nature, and obliges him to confess what he is, to renounce his monstrous and misshapen forms, and to exhibit himself in his orderly, comely, and divine lineaments."

Concerning conjectures and speculations, the following remarks occur in a lecture for 1809: —

"Upon all occasions, when I venture upon a conjecture, you will, I trust, have the goodness to consider it as brought forward, not as an opinion which it would be painful to relinquish, but as a hint which may lead to inquiry. Indeed, speculation should always be regarded in this point of view, and, except when it has its source in facts, and its termination in experiments, ought to be rejected as dangerous and unprofitable. Hypothesis should be considered merely as an intellectual instrument of discovery, which at any time may be relinquished for a better instrument. It should never be spoken of as truth; its highest praise is verisimility. To be attached to mere speculation is to be directed by a dream. Knowledge can only be acquired by the senses: nature has no archetype in the human imagination; her empire is given only to industry and action, guided and governed by experience."

Relative to the enigmas of science he says, "There will always be enigmas for us in nature as in philo-

sophy, which will keep alive the faculty of research, and the active power of investigation. And it is much wiser to rejoice that *something* has been discovered, than to regret that so much is still concealed from us."

In another place, confessing his inability to solve certain problems in electro-chemical science, he says, —

"I make these confessions of ignorance, rather with a feeling of pleasure and of hope, than of uneasiness and humiliation;" and he immediately adds, "Insulated, striking, but unexplained facts in science, are to the philosopher what green branches and fruits in the ocean are to the mariner voyaging for discovery; they are omens of land, which, even though he himself should not have the felicity of attaining, he may yet indicate to others.

"I hardly know which we ought most to rejoice at—the progress that *has* been made in natural knowledge, or the progress that *is* to be made. If a limit could be obtained, if we could rest satisfied with what is known, how great a source of activity, profit, and pleasure, would be destroyed! And we cannot be too grateful for that wonderful constitution of the external universe, by which it is rendered an inexhaustible source of interest to the inexhaustible human mind; by which it is so admirably adapted to keep awake that happy curiosity, which is a constant germ of improvement; that noble kind of ambition which continually tends to exalt the intellectual being; that flame of life, unquenchable even in the fountains of knowledge."

Alluding to some wild speculations, in which irri-

tability, and even sensibility, were referred by the early inquirers to electrical powers, he remarks: —

"In the early stages of discovery, the imagination is often dazzled by the brilliancy of the new facts, and trusts to weak or remote analogies. The whole language of nature informs us, that in animated beings there is *something above our powers of investigation;* something which employs, combines, and arranges the gross elements of matter, — a spark of celestial fire, by which life is kindled and preserved, and which, if even the instruments it employs are indestructible in their essence, must itself, of necessity, be immortal."

On the beneficial influence of doubt in science, he thus expresses himself: —

"It is a great matter that we should put no improper confidence in any notion or doctrine. Doubt in physical research is highly salutary, and is always the parent of inquiry, and often of truth. Though our reasonings may have the perfect character of verisimility as applied to known objects, yet we have no right to say that our view is an ultimate one; our system of logic cannot unfold all the resources of nature. The maxim of a chemical investigator should be that adopted in the motto of an illustrious society, 'To rely on the word of no master.' Nothing has so much checked the progress of philosophy as the confidence of *teachers* in delivering *dogmas* as truths which it would be presumptuous to question. It was this spirit which, for more than ten centuries, made the crude physics of Aristotle the natural philosophy of the whole of Europe. It was this spirit which produced the imprisonment of the elder Bacon, and

the recantation of Galileo. It is this spirit, notwithstanding the example of the second Bacon, assisted by his reproof, his genius, and his influence, which has, even in later times, attached men to imaginary systems, to mere abstracted combinations of words, rather than to the visible and living world, and which has often induced them to delight more in brilliant dreams than in beautiful and grand realities."

In a lecture for 1810, noticing a chemical process which he believed might prove useful to the arts, and lucrative to any individual who might employ it, he says, "I have disclosed all that I know upon the matter; and it will be a source of infinite satisfaction to me, if the publication of these statements should lead ingenious men into the path of inquiry. You, I trust, will do credit to my motives. I have no wish to conceal any thing which may be a source of profit even to others; for I hold *that science* in little estimation which is applied to selfish commercial speculation: the true object of discovery should be knowledge and intellectual power; and these cannot be purchased by thousands, and, in my humble estimation, are equivalent to millions."

I shall give one extract more. It is from a lecture on geology, relative to the end and objects of scientific research and the use of speculation. They were subjects to which he attached great importance, and his views respecting them he seldom lost an opportunity of expressing: —

"In the investigation of geology, as in almost all other inquiries to which the human mind has been ardently devoted, very few speculations have indeed been formed, not possessed of some immediate or remote applications to the real progress of science.

The understanding is permanently guided by experience; and brilliant delusions, even though consecrated by the efforts of genius, cannot very long continue to deceive the public. Useful truths are often ascertained in the attempts made to detect imposing errors; and the appeal to experiment, which is the last and the only certain test of the merits of opinion, can hardly fail to lead to discovery. Hypothesis uniformly produces discussion; and the more ingenious, and the more active, the talents by which it was formed, the greater is the probability of a minute and serious examination of facts. To explain nature, and the laws instituted by the Author of nature, and to apply the phenomena presented in the external world to useful purposes, are the great ends of physical investigation; and these ends can only be obtained by the exertion of all the faculties of the mind; and the imagination, the memory, and the reason, are perhaps equally essential to the development of great and important truths."

Of distinguished men of science, Mr. Cavendish, Dr. Priestley, and Scheele, were the three chemists on whose characters my brother most delighted to dwell, and to hold up to admiration; and after the names of Bacon and Newton, theirs must have most frequently recurred to his memory, and are most frequently mentioned in his lectures. He appears to have considered them as exemplars of *knowledge*, *curiosity*, and *genius*. His sketches of them are given according to his own peculiar views of the methods of science; and they mark strongly his opinion of scientific merit, and the high respect in which he held it, in its different grades. Of Mr. Cavendish there is the following notice in a chemical lecture of

1810, when his loss was recent; and it was in considering the progress of chemical discovery, and the contributions made to it in particular by this eminent philosopher, that he thus digresses into the character of the man: —

"Of all the philosophers of the present age, Mr. Cavendish was the one who combined, in the highest degree, a depth and extent of mathematical knowledge with delicacy and precision in the methods of experimental research. It may be said of him, what can, perhaps, hardly be said of any other person, that whatever he has done has been perfect at the moment of its production. His processes were all of a finished nature. Executed by the hand of a master, they required no correction; and though many of them were performed in the very infancy of chemical philosophy, yet their accuracy and their beauty have remained amidst the progress of discovery, and their merits have been illustrated by discussion, and exalted by time.

"In general, the most common motives which induce men to study are, the love of distinction, of glory, or the desire of power; and we have no right to object to motives of this kind; but it ought to be mentioned, in estimating the character of Mr. Cavendish, that *his* grand stimulus to exertion was evidently the love of truth and of knowledge. Unambitious, unassuming, it was with difficulty that he was persuaded to bring forward his important discoveries. He disliked notoriety, and he was, as it were, fearful of the voice of fame. His labours are recorded with the greatest dignity and simplicity, and in the fewest possible words, without parade or apology; and it seemed as if in publication he was performing, not

what was a duty to himself, but what was a duty to the public. His life was devoted to science, and his social hours were passed amongst a few friends, principally members of the Royal Society. He was reserved to strangers; but, when he was familiar, his conversation was lively, and full of varied information. Upon all subjects of science he was luminous and profound; and in discussion wonderfully acute. Even to the very last week of his life, when he was nearly seventy-nine, he retained his activity of body, and all his energy and sagacity of intellect. He was warmly interested in all new subjects of science; and several times in the course of the last year witnessed, or assisted in, some experiments which were carried on in this theatre, or in the laboratory below.

"Since the death of Newton, if I may be permitted to give an opinion, England has sustained no scientific loss so great as that of Cavendish. Like his great predecessor, he died full of years and of glory. His name will be an object of more veneration in future ages than at the present moment. Though it was unknown in the busy scenes of life, or in the popular discussions of the day, it will remain illustrious in the annals of science, which are as imperishable as that nature to which they belong; and it will be an immortal honour to his house, to his age, and to his country."

In the same lecture he describes Dr. Priestley, who, with different qualities, and powers of mind inferior to Cavendish, obtained as brilliant success in the same pursuits by a different method, in which activity and enterprise, and the love of truth and of discovery, were predominant: —

"Stimulated by the examples of Dr. Black and Mr. Cavendish, Dr. Priestley, about the year 1770, applied himself with intense ardour to experiments on the subject of air. By a constant application of the combinations and agencies of the various chemical substances, he discovered oxygen gas, nitrous gas, nitrous oxide, and light carburetted hydrogen; and, by using the mercurial apparatus, he exhibited several of the acids in an aëriform state, and demonstrated their properties. As a discoverer, Dr. Priestley stands in the highest rank; and it is scarcely possible to advance a step, or to perform a process in pneumatic chemistry, without having recourse to his methods, and making use of substances he first exhibited. His activity was unceasing; and in physical science all his exertions were crowned with success. His experiments, though neither accurate nor minute, were almost always upon subjects of importance; he made up for the defect of his manipulations by the rapidity of execution, and the novelty of his methods. He prepared the way for more accomplished chemists; he furnished them with matter of inquiry; and, in the true spirit of liberality, offered to the world all his treasures of science. He was as the miner, who discovers hidden riches, and furnishes them in the unwrought state to the cunning artist; the ore that he brought to light was crude, but it was precious and useful. To theory Dr. Priestley paid but little attention; and his hypotheses were rapidly formed, and relinquished with an ardour almost puerile. His chemical writings are principally narrations of facts; and though the style and arrangement are defective, from hasty composition, yet it is impossible not to be amused and interested by his details. They

are copious, distinct, and satisfactory; and the manner in which they are pursued leaves a very favourable impression of the simplicity, the ingenuousness, and candour of his mind.

"Dr. Priestley was a discoverer before he was a chemist. In a letter, which I received from him a few months before his death, he makes this statement, in his usual unaffected manner. It is easy, therefore, to find a reason for the occasional incorrectness of his views. Throughout the whole course of his life his attention was never undivided. His mornings were devoted to experiment; his evenings to political, theological, or metaphysical inquiries. He is an example how much may be done by small means, when applied with industry and ingenuity, and how easy it is, in some instances, to enlarge the boundaries of chemical knowledge; and how much more real and permanent glory is to be gained by pursuing the immutable in nature, than the transient and capricious in human opinion. When Dr. Priestley's name is mentioned in future ages, it will be as one of the most illustrious chemical discoverers of the eighteenth century."

In the next lecture, the subject of which was nitrous gas, he gives some further particulars of Dr. Priestley; and especially of the kind of apparatus used by him. Having observed that he "knew no book so likely to lead a student into the path of discovery as Dr. Priestley's six volumes upon air," he continues: —

"His most important experiments were made with apparatus of the most simple kind. His grandest and most expensive instrument, like that of Dr. Hales, was a gun barrel. He used phials and bent tubes

for retorts; a wash-hand basin often served him for a pneumatic trough, and instead of porcelain tubes he employed tobacco pipes; and with this simple machinery he discovered a greater number of new substances than any philosopher of the last century."

I shall extract the next paragraph of the lecture, describing the manner in which nitrous gas was discovered by Dr. Priestley. It is a good example of the manner in which he made his discoveries, and it also well displays the acumen of intellect of Mr. Cavendish.

"Dr. Hales has mentioned in his statical essays, that, during the solution of a mineral, which he calls Walton Pyrites, and which must have been a common pyrites, he procured air, which, when mixed with common air, gave a turbid red fume. Dr. Priestley, in mentioning to Mr. Cavendish that he wished much to witness the phenomenon, but that he despaired of ever procuring Walton Pyrites, was advised by Mr. Cavendish to try *any* pyrites, or metallic substances; for he had no doubt that the properties of the air depended upon the spirit of nitre, the nitrous acid, and not upon the substance dissolved. This hint led to the knowledge of the properties of a new elastic fluid: Dr. Priestley first procured nitrous air by dissolving brass in nitrous acid."

To the high merit of Scheele he pays the following tribute of generous admiration:—

"I have mentioned Scheele as an admirable experimenter. As, in the last lecture, I endeavoured to do justice to the philosophical labours of Cavendish and Priestley, I shall, with the same kind of feeling, refer to the exalted character of the only foreign philosopher of the last century, whose merits as a dis-

coverer can be at all put in competition with those of our countrymen.

"Scheele offers an extraordinary instance of the power of genius to conquer difficulties, and to create resources of its own. Born in a country town in Sweden, without friends, and without fortune, he seemed, by a disposition which may be called almost instinctive, to have pursued the study of chemistry. He was brought up as an apothecary and druggist; and led, by the circumstances of his business, to attend to some of the chemical qualities of substances employed in pharmacy, he instituted a train of investigations, which gradually led to discoveries of the noblest kind. Scheele, amidst the labours of an unprofitable occupation, found means of exalting and extending the most refined parts of chemistry. His days were devoted to a laborious business; his nights to solitary study. Using the common apparatus of pharmacy, he performed the most delicate manipulations, neither seeking fame nor profit by his labours; for, till he became acquainted with Bergman, he was ignorant of the honour which would result from discoveries: neither seeking fame nor profit, he pursued science, because his mind was imbued with an unquenchable desire for truth. Nothing could repress the ardour of his mind, nor damp the fire of his genius; and his short life was a career of enterprise and of glory. Scheele made known at least thirteen new bodies; and his chemistry may be called almost his own creation. His theories were formed with boldness, but he attached no importance to *them* except as the mere links for the connection of facts. He was the faithful disciple of the school of Bacon and of Newton.

"At the time that Scheele began his chemical labours, about 1772, Bergman, professor of chemistry at Upsal, was the great scientific luminary of Sweden. He had distinguished himself by some very profound investigations concerning chemical attraction, and had ascertained some important facts respecting metallic bodies and neutral salts. The manner in which Bergman brought forward Scheele is highly honourable to the scientific character of the country. He wrote a preface for his first work, was his friend and protector, and, relinquishing the venerable authority of his chair, he became the disciple of a young man as yet unknown to the world. It has been said of Bergman, that 'his greatest discovery was the discovery of Scheele.' It may, perhaps, likewise, be said, that his greatest glory was the glory of raising and exalting merit, even though it was in acknowledging his own inferiority. Such examples are very rare. There are few instances of such sacrifices of selfish feelings; and that they should be faithfully recorded is necessary for the honour of human nature, and for demonstrating, to use the language of Bacon, borrowed from Scripture, that 'wisdom is justified of her children.'"

In another lecture, in which he has noticed the character of Scheele in similar terms of the highest praise and admiration, he says: —

"I have been drawn into this eulogium, not merely because it is fully deserved, but because the example of Scheele demonstrates what great effects may be produced by small means; how little is required to extend the empire of knowledge, when genius is assisted by industry."

In illustration of his views of science, and of the

manner in which he made biographical notices auxiliary to instruction, and to the exciting a lively and worthy interest in the minds of his audience, I might transcribe many other sketches of the characters of distinguished men, from his lectures; but that this part of my work may be kept within moderate bounds, I shall add three more only: one of the elder Pliny; one of the second Bacon; and the third of Newton: the two first taken from his early geological lectures; the third a fragment. Even were they merely ideal delineations, they would have a value.

After having remarked that the philosophy of Rome was little more than an imperfect copy of that of Greece, he says: —

"The only Roman who really deserved the title of an investigator into nature was the elder Pliny. This illustrious person possessed the highest degree of industry, and an ardour in the pursuit of knowledge which no difficulties could repress. He considered all the productions of the earth as worthy of attention, either for their order, their beauty, their uses, or relations to man. Possessed of such requisites for discovery, he was still deficient in the great characteristics of a strong mind and a philosophical spirit. Endowed with a simple heart, and, apparently, incapable of deceiving, he believed almost whatever was related to him; doubt seemed to be a stranger to his understanding. He beheld things in their obvious forms with delight and with wonder, and, satisfied with what he saw, he seldom attempted to refer effects to their causes. Endowed with none of the high elements of reason, — with none of those restless workings of the imagination which produce new combinations of ideas, new truths, and new inventions,—he was nevertheless a minute observer and a faithful

historian, but neither an experimental philosopher nor a man of genius."

Of Bacon he remarks, speaking of the period in which he lived: —

"Many scientific persons, before Bacon, had pursued the method of experiment in all its precision, — many had dared to despise the logic and forms of the ancients; but he was the first philosopher who laid down plans for extending knowledge of universal application; who ventured to assert, that all the sciences could be nothing more than expressions or arrangements of facts; and that the first step towards the attainment of real discovery was the humiliating confession of ignorance. Bacon was prepared by nature, by education, and by his habit of study, for effecting the great revolution in philosophy. His knowledge was extensive; his instances were copious; his genius was equally capable of developing the lighter and more profound relations of things. He possessed a strong feeling, but it was uniformly directed by reason; he was gifted with a vivid imagination, but it was tempered and modified by a most correct taste and judgment. The influence of rank and of situation assisted his views. The public was prepared to receive them; and he was enabled to advance his opinions in full confidence that they would be adopted with reverence in his own time, and that they would carry his memory into future ages with great and with unchanging glory."

He immediately adds, "The pursuit of the new method of investigation, in a very short time, wholly altered the face of every department of natural knowledge; but its influence was in no case more distinct than in the advancement of geology and chemistry.

Though much labour had been bestowed upon these extensive fields of investigation, they had hitherto, as it has been seen, been little productive. Speculation had been misplaced, observation confined, and experiment principally directed, rather towards impossible than to practical things. In the novel system, hypothesis was exploded, except as a guide to actual trials; combinations of thought were considered as truths only when conformable to nature, and not when they merely expressed the caprices of the imagination; and those inquiries only were considered as valuable, which were made upon the hidden sensible properties of things, and upon the existing relations of facts."

On Newton are the following reflections: —

"There are undoubtedly, in science, fortunate combinations; there are happy times, in which new inventions bestow new powers, and in which men are, as it were, compelled to follow an easy path to glory; but, for all this occasional interference of accident, labour,—steady and *uninterrupted labour*,—and the virtue of continued attention, are the true sources of noble and happy discoveries; and whoever possesses these enviable habits of mind has the chief and the most certain elements of success. In the study of nature there can be no exertion thrown away; for the general laws belonging to it are no less simple and grand, than the economy which they govern is complicated and minute; and, when observation is carried as far as the senses can reach, it is still capable of being rendered more accurate, by means of the different apparatuses of instruments, which are constantly becoming more perfect; so that the philosopher, who, having ascertained great truths in a

particular department of science, should pretend to fix them as limits, would act as ridiculously as that Danish king who commanded the ocean to stay its waves. When Newton was asked by Dr. Pemberton, to what he owed his great discoveries, he said, to his habitual and patient attention; and the same great man, in a conversation in his later years, upon the progress of discovery, having asked, 'what was doing at Cambridge,' and being answered by Dr. Barrow, that 'there was nothing doing,' that he had 'occupied all the ground,' jocosely said, 'Beat the bushes, and there is still plenty of game to be raised.'

"Original profundity of genius, talents for abstracted research, and vigorous constitution of mind, combined with sagacity and acuteness, are undoubtedly associated with the powers by which lofty truths are attained; and they belonged, in the highest degree, to the author of the Principia, and the Optics; but these alone, though essential to the development of his abilities, would have accomplished nothing, without the faculty of continued exertion, which induced him to pass successive nights and days in contemplation, inattentive to the wants of the body; which enabled him to attain that sublime state of intellect, in which all sensible objects are excluded, and in which the mind was nourished by its own thoughts concerning the laws of the heavens and the earth made the subjects of active meditation."

In illustration of his manner of treating the sciences which were the subjects of his lectures, I shall now give only a small number of specimens: in the course of the work opportunities will occur of adding to them, especially in exemplification of his

manner of exciting an interest in the minds of men of science, by communicating discoveries as they were made; and of making his audience, as it were, spectators and participators of the progress of discovery. The following extract from a lecture of 1810, both gives a distinct idea of the nature of chemical attraction and a history of its discovery, with a vindication of the right of Newton to the glory of having laid the foundation of chemical philosophy: —

"By a singular concurrence of circumstances it was reserved for the same great genius who developed the laws of the planetary system, and who unfolded the harmonious movements of the great masses of matter in the universe,—it was reserved for Newton to lay the foundation of the first theory of chemical action, and to solve the diversified phenomena of corpuscular changes, by a great and universal principle, similar to that which he had before applied to the phenomena of the heavenly bodies. Newton, towards the close of his life, was made Master of the Mint; and that this office was once bestowed upon a man of science, was a great and glorious circumstance for the progress of chemistry. Newton performed the duties of Master of the Mint, and made a number of experiments upon metallic solutions and alloys. He discovered several new alloys, particularly that of a mixture which fuses at the heat of boiling water, and which is composed of lead, tin, and bismuth. In reasoning upon the phenomena of the dissolvent powers of acids, his sagacious mind at once perceived the extension of an order which prevailed with respect to the great arrangements of matter. Sugar dissolves in water, alkalies unite with

acids, metals dissolve in acids. 'Is not this,' said Newton, 'on account of an attraction between their particles? Copper, dissolved in aquafortis, is thrown down by iron. Is not this because the particles of the iron have a stronger attraction for the particles of the acid than those of copper? and do not different bodies attract each other with different degrees of force?' *

"A principle, at once so beautiful and simple, and enforced by the authority of such a master, was immediately adopted. Geoffroy, the most able chemist in the Academy of Science, two years after Newton had published a complete development of his chemical opinions, attempted to make a table of chemical attractions, and to show, by numerical expressions, the powers which bodies have of separating each other from solvents. His manner of doing this was, however, far from being generous. He changed the name of *attraction* to that of *affinity*, and made no mention whatever of the original inventor in his paper. Though the principle was referred to Newton by Senac, who published an elementary book on chemistry, in French, in 1723; yet still the authority of Geoffroy, and his successors in the academy, who produced several popular elementary works on chemistry, influenced, in a higher degree, the public opinion, and for a long time the erroneous and vague term, affinity, was substituted for a word which implied the simple expression of a fact.

"The greatness of the reputation of Newton, at this period, rendered his own countrymen almost indifferent to his claims in chemical philosophy. In

* Newton's Works, 4to. vol. iv. p. 242.

the abundance of the rich stores which he afforded to science, such a small contribution was hardly missed. The controversy concerning the invention of fluxions was of a higher character; and the lustre of his mathematical philosophy, in some measure, threw his chemical discoveries into shade. But justice is the first principle of philosophical history. It is not with the vain idea of adding to the reputation of Newton, that I make these statements; not from the unworthy motive of expressing feelings of nationality; but for the sake of following truth, and of attributing glory where glory is justly due."

In a lecture of 1811, is the following passage relative to elementary matter, which cannot be too strongly impressed on the mind of the young chemist. Speaking of the elements of the elder chemists, of their sulphur, oil, and salt, he remarks: —

"These ideas are equally unpoetical and unphilosophical; the productions of rude minds directed to coarse operations, and guided neither by refined observation, nor taste."

"In modern chemical philosophy (he continues) all views of known *ultimate indestructible* elements are discarded. Those forms of matter which have not yet been changed by art are considered as *undecompounded*, but this is merely with respect to the present state of knowledge. The experimental philosopher does not consider those substances which are elementary to him as necessarily elementary in the great operations of the universe. He merely follows nature in the path of experiment. The number of principles not decompounded is consequently in a state of change. Till very lately,

the earths, the alkalies, and certain acids, were considered as elements; but all these it has been my good fortune to decompose. The arrangements of the science change with every new acquisition of facts, and approximations only are made to truth."

The next extract is from a lecture of the same year; it occurs after an account of Mr. Cavendish's hypothesis of combustible bodies being compounds containing hydrogen, and combustion a union of oxygen with the hydrogen of the burning bodies: —

"The odium connected with the word phlogiston was a just one. It was sometimes regarded light, sometimes ether, sometimes heat, sometimes weighty, and at other times imponderable. If the theory of combustion had been discussed as the theory of combination of oxygen and hydrogen, or oxygen and combustible bodies, some premature generalisations might have been avoided. The great glory of Lavoisier was that of introducing a strict logic into chemistry: but the logic of Cavendish was equally refined. The French philosopher was confident of the truth of his generalisations. The English philosopher permitted himself to doubt. His sagacious genius led him to conceive, what we are every day finding to be the case, that modern chemistry is in a state of infancy; that we are little acquainted with the real nature of the elements; and that our theories are merely temporary arrangements, the great merit of which is that they connect established facts together, and direct us in the research after new facts."

The next extract is from a lecture of 1810, and consists chiefly of rough notes for lecturing from; they appear to me deserving of insertion in this place, not only on account of the impressive manner of

teaching they display; but, also, as showing his latest views of the nature of heat, which have often been misinterpreted, and how readily he gave up an hypothesis, however brilliant, when no longer consistent with facts.

Having shown, by means of the great battery of 2000 plates, the fusion of the most refractory metals, he remarks: —

"These experiments, as well as those which I have before exhibited, do away the opinion, which many able writers have supported, of a *cold* fusion by electricity; a notion which has been lately revived by M. Benthollet. It cannot be said that the electricity merely increases the oxydability of the metals, and thus produces their combustion; for the phenomenon takes place, with even more energy, in vacuo if platina wire be used."

Having shown this experiment of intense ignition of platina wire in a vacuum, he made the following commentaries on it. On this fire, where there was "no atmosphere, and a perfect insulation," he says: —

"The fact is the strongest one that I am acquainted with, against the notion of heat being a peculiar *subtle fluid*, which cannot appear, unless given off from some combustible. The air cannot give it, for there is none. Let it be said to be *composed* of the *two* electricities; *i. e.* let them be regarded as different subtle fluids; but, in *this case*, cold ought to be produced in some part of the system. I once had this idea. It satisfies the imagination, but not the *reason*. If we suppose *one fluid*, and this fluid carries heat with it, whence can its heat be derived? If we conceive it to be heat or light, why *should* it be resolved into heat or light the moment that it is

strongly attracted by matter? Let the *heat* be said to be pressed out from the *metal;* but then there must be an equilibrium. No theory is consistent but that of heat being matter in a state of motion; and of electrical charge being successions of attractions and repulsions, producing these motions. But, it is said, there *must be matter ;* true: but the question is, whether this is specific? whether different kinds of matter, when projected into free space, may not become heat? The notion argued against is one simple, specific, indestructible *fluid* of *heat.* There are a great variety of gases: suppose the particles of hydrogen could be made to pass through free space; they would, perhaps, be *heat*, suppose them to expand as much.

"The particles producing terrestrial heat seem different from those producing solar heat: so of light.

"Vulgar idea—like that of the peasant, every thing done by a spring; so every thing must be done by a fluid. The ether was the ancient fluid; then there was a phlogistic fluid: we have had the magnetic fluid, the vitreous fluid, the résinous fluid; and within the last few years there has been a fluid of *sound;* and, in a book, which I lately received from France, published by M. Azais, all the phenomena of nature are explained by a gravic fluid.

"But it is said that nothing but matter can pass through *bodies*, and that therefore there must be some fluid concerned, — a strong argument in the perforation of a card, by the discharge of an electric battery, exhibiting a burr on both sides; but if *something* absolutely passed through, the burr could only be on one side, unless there are two fluids created in the middle of the paper, one of which passes one way, and the

other another way. On the idea which I have ventured to form, both the interior and the exterior of the paper are violently attracted, and will be separated; one towards the positive side of the jar, the other towards the negative."

The following extract from a lecture on oxygen for 1811, exhibits a good instance of the original views by which he fixed the attention of the philosophical part of his audience: —

"The whole series of discussions that have been brought forward prove that oxygen is a body very prone to enter into combination, and with great energy, and usually produces light, and always heat. The compounds that it forms differ according to the nature of the body with which it combines. Thus, with hydrogen, it forms a neutral compound; with sulphur, a strong acid; with potassium, a corroding alkali; with iron, an insoluble tasteless body; and with certain metals, it forms earths. *Oxygen*, therefore, or the *producer* of *acid*, is a very improper name for it; for there are very powerful acids which do not contain it, and it exists in the most energetic alkalies. It might be called, with more propriety, hydrogen, the producer of water; or alkaligen, or geogen; but all these names are equally exceptionable. At present, it is better to continue the name of oxygen, and to wait for a more mature period of the science for the reform of the nomenclature."

I shall give only one extract more from his chemical lectures: from the seventh lecture of the course for 1809, in which he demonstrated, for the first time publicly, the decomposition of boracic acid. After having given a detail of the experiments which he had made to endeavour to decompose muriatic acid,

on the old hypothesis, of its consisting of a base and oxygen — experiments which, he said, had occupied a considerable portion of his time and attention during the preceding twelve months, without enabling him to arrive at any satisfactory conclusion respecting the nature of the acid, he proceeds: —

"The boracic acid, the substance I am now about to mention, has proved much less refractory, and has afforded satisfactory evidences both of decomposition and of composition, giving results as pure as those obtained by the analysis and synthesis of carbonic acid.

"*Boracic acid, how obtained. Properties.*

"*My first Experiments—Voltaic.*

"*Later ones.*

"*Potassium.*

"*Substance obtained.*

"*Combustion in a glass tube shown.*

"Boracium.

"You see this substance in the largest quantity in which I have procured it; and you are the first persons in this island who have witnessed this novel creation of experimental science.

"Combustion in oxygene gas.
("Quere, in oxymuriatic acid?)

"When this new substance, boracium, is better known, it will, I doubt not, be employed towards purposes of utility; but it is not during the infancy of a discovery that its relations to the useful arts occur. The first object of experiment is to discover truths; the second, to apply them to the purposes of life; and *facts*, that extend the boundary of know-

ledge, cannot but be *beneficial* in their immediate as well as remote tendencies, and are, I trust, always dignified objects of pursuit."

From his Geological Lectures, I am tempted to make a few extracts. The subject of them, generally, was well fitted to the powers of his mind; and to display how, in his researches, his imagination, after its first wild flight in youth, was ever after under the controul of judgment, even when most active; and how he made speculation always subservient to observation and experiment.

The first extract I shall give relates to the mystery of the origin of the primary rocks: it is from the course which he delivered in 1811. The remarks arose in considering the hypothesis of Dr. Hutton: —

"The hypothesis of Dr. Hutton, like that of Werner and of Kirwan, has been principally founded upon conjectures; for, as yet, there are no positive proofs that the principal materials of our globe are either soluble in water, or capable of being fused by fire, and deposited in regular forms in consequence of cooling. The masterly experiments of Sir James Hall have, indeed, shown that basalt, rendered fluid in our furnaces, may be crystallised by a slow diminution of temperature; and that limestone may be fused under great pressure, without losing any of the elastic fluid with which it is combined. But no strong analogies can be applied from these most interesting facts to granite, to the regularly formed gems, or to any of the perfectly aggregated rocks containing no organic remains. The general theory is almost as obscure as before. The early operations of nature are unknown; and the laws of the formation of the habitable globe are still almost as little

understood as those of the production of the general planetary system — of the sun, and of the fixed stars. We are informed by Clemens Alexandrinus, that the Egyptian priests made a statue of the god Serapis, in which they blended together all the known metals, and all the soils commonly found in Egypt; and this statue has been supposed to represent the primordial state of things. A useful lesson, at least, may be derived from the narrative. No person uninstructed in the history, supposing the image now existing, would be able to reason from the *form* concerning the *materials;* and no person, from viewing the materials, would be able to develope the means by which they mingled, or the end for which they were designed. The powers of man are scanty and definite; even the origin of certain and well-known human productions, have hitherto baffled all his inquiry. He is unable, satisfactorily, to explain the erection of the pyramids of Egypt, or of the Druidical pillars of Stonehenge; and yet he is sufficiently daring to endeavour to apply his mind to the grand operations which have been produced by Divine intelligence; to attempt to explain the changes that have taken place beneath the foundations of the earth; to examine the great laws of the creation of the systems of the universe, and to reason concerning their origin in that infinite space which he is wholly unable to penetrate, and even accurately to imagine."

The next extract contains his reflections preliminary to entering on the consideration of the origin of the secondary rocks. They are also from his second course of lectures: —

"In considering the secondary strata, filled with or-

ganic remains, and containing the vestiges of many beings analogous to living generations, it is scarcely possible to avoid speculation; and even the most cool and sober understanding is almost irresistibly led to form ideas concerning the state of things existing at their origin, and concerning the powerful material agents subservient to those great natural events, the occurrence of which is demonstrated by their arrangement and wonderful appearances. The subject is one of high interest, but it ought to be pursued with considerable caution. Men possessing very brilliant talents have differed essentially upon it; hypotheses have been multiplied with regard to it; and much ingenuity and labour have been employed upon the discussion.

"In accounting for the *present* order of things, we are enabled constantly to appeal to the senses, to combine observation and experiment; but, in attempting to explain the past *change* in nature, if we are in possession of no distinct history, analogy is our only guide. Inferences must be made from known facts concerning the unknown; and the mind, if unable to obtain certainty, must rest satisfied with strong probability. None of the facts concerning the formation of the secondary rocks can be immediately known; all our reasonings upon them must be inductive; they must be founded upon the knowledge of the properties of the substances that compose the strata, and of the agents by which these substances are capable of being modified. And where causes can be plausibly developed, it must be from the examination of existing operations, that produce appearances similar to those which are the objects of inquiry."

As an example of this kind of investigation which

he proposed, I shall give his remarks on the formation of coal:—

"On the subject of the origin of coal (he says), there have been various opinions; but the vegetable and animal impressions it contains, as I mentioned in the last lecture, ought to lead, with much minute discussion, to the theory of its production. Where wood has been buried in the earth in late times, from the action of water and of air, it always undergoes a change, which brings it to a state similar to that of pit coal. At Bovey, in Devonshire, a whole forest is found buried under different strata of clay and gravel; and the trees, though carbonaceous, and black, have their ligneous form, and contain a substance apparently intermediate between bitumen and resin, as has been shown by Mr. Hatchett. A similar species of coal is found in Sussex, and in Iceland, where it is called Surtabrand, and the pieces appear flattened from the pressure of the superincumbent mass, during the time of the conversion of the wood into coaly matter.

"Vegetable and animal substances may, however, likewise be converted into a body resembling pit coal, by heat under pressure. Sir James Hall has shown this, making use of the same means as those employed in his experiments upon limestone. He has proved that, by a strong heat, applied to different animal matters, and different species of wood, in close vessels, a substance is produced, black and glossy, and having properties different from those of common charcoal, as it burns with a dense flame, giving out volatile matter. Sir James has adduced his experiments as proof of the Huttonian theory of the igneous origin of pit coal. His arguments

are, in the highest degree, ingenious; and, if the insulated facts only were to be considered, very forcible and convincing. But, when the usual strata above and below coal are examined, it is scarcely possible for the impartial observer to suppose that they had been subjected to heat. They are principally loose sandstone and loose schist, bearing every mark of having been deposited from a state of mechanical suspension in water. The agency of water, and the natural process of decomposition, to which all organised matter is liable,—this seems fully adequate to explain the appearances of the coal strata. Vegetable matter, in its first state of change, appears as peat; in another and more advanced state, it is the same substance as Bovey coal; and when the bitumen is completely formed, it is the true fossil coal, in which the ligneous texture is sometimes evident, and sometimes destroyed. In a quarry near Glasgow, vegetable matter is found in almost all its different states of conversion. Near the surface, it is but little decomposed; and here it occurs in a very imperfect sandstone, apparently of late formation. In a lower stratum, about ten feet below, it has the appearance of wood slightly charred; and, in the compact and white sandstone, which is used for building, it occurs converted into bituminous coal."

I shall conclude these extracts with his observations on the formation of the secondary strata, and his remarks on the use of hypothesis. The view of the formation of this class of rocks which he then took was different from that which he preferred some years later, described in his posthumous work, "Consolations in Travel," as was quite in accordance with his ideas of the proper mode of employing hypothesis:—

"Concerning their general arrangement, and the revolutions in nature connected with it, I have as yet offered no supposition; but this part of the subject necessarily follows in the order of discussion. All the appearances, all the different facts, show, in the most decided manner, that the various strata filled with organic remains were covered by the sea at the time of their production. This is the ancient theory, which will not be disputed, though many modifications of it may be formed; and various arguments must be stated, before it can be decided whether the strata were formed by slow operations or by rapid changes; whether they were the work of days or of ages; and whether the present land was anciently the bed of the ocean, or whether the secondary rocks were formed upon it by a great influx of waters.

"There are no distinct appearances which demonstrate a very slow and gradual deposition of the secondary strata; but there are very many which show, at least in some cases, the effect of their formation must have been sudden and rapid. Fishes, the organised matter of which so easily consumes, have left their impressions imbedded in the hardest rocks; and these impressions often exhibit the perfect and unaltered form. Other marine animals, likewise, of a still more delicate organisation, exhibit vestiges of their remains in an undecompounded substance. The various appearances would seem to indicate that these different beings had been suddenly destroyed in the strata that contain them. The various remains of the land animals found in sandstone alternating with shell limestone offer another indication of the waters having covered the place of their abode; and

that these waters flowed in upon a great extent of country, and rushed over the surface with considerable force, seems evident, from the transportation of the remains of the animals, which are now only found within the tropics, toward the poles. The bones of the rhinoceros, and of the elephant, have been found in Siberia; the tusks of the elephant, and the bones of the crocodile, have been discovered in this country. Astronomical deductions seem to show that these appearances cannot result from a change of climate, arising from a change of the inclination of the axis of the earth. And when all the evidences are examined, and all the various oppositions and agreements of facts discussed, there seems to be no period to which the production and arrangement of the secondary rocks can be so well referred, as to that of the great inundation of the waters upon the land, recorded both in sacred and profane history, and of which so many testimonies are preserved in nature, and of which so many traditions have been brought down from the elder nations, and from the most remote times. We perceive the effects of this great catastrophe, but the immediate material cause of it can never be distinctly developed. The hypothesis of Leibnitz, extended by Whiston, that it was produced by the attraction of a comet upon the waters of the ocean, is, perhaps, the most plausible that has been advanced; and, when taken with limitation, the most adequate to the explanation of the phenomena. Supposing that a large comet approached near to the earth, having a power of attraction sufficient to raise the tides to the utmost height of our mountains; and supposing, likewise, that it was on its return from the sun, and capable of communi-

cating heat to the water, its influence, there is great reason to believe, would be fully adequate to produce the various effects that have been discerned, and to occasion those great and diversified changes exhibited by the secondary surface of the globe. Assuming an elevation of temperature of only 180°, where the ocean was elevated into the tides, which, in itself, would not be destructive to life, there is great reason to suppose that the solvent agency of the water would be sufficiently increased to enable it to combine with the different earths, though the other parts of its surface, from its bad conducting power, might remain comparatively cold. The waters of the ocean in rushing over the different parts of the land would necessarily carry with them their living inhabitants, and many of the substances forming their bed. Where forests were overwhelmed, layers of coal would be produced; where calcareous soils were torn up, strata of chalk would be formed; and the sand from the shores, and from the depths of the sea, deposited at the same time with dissolved earthy matter, would produce the varied cemented stones and breccias. The general effect of the action of the sea would be increased by the rapid evaporation at the point of attraction, and from the deposition of torrents of water in the more remote parts. In the great series of changes, rocks that had been covered by the sea would be laid bare; many high lands would necessarily be broken down, and levelled into plains; the forms of mountains would be changed; and the productions of one country carried into another by the rapid impulse of the waves.

"It would be easy to offer still more minute elucidations of the opinions of Leibnitz; but to multiply

imaginary instances is, perhaps, to indulge too much in the spirit of speculation. Whatever may be the cause assigned for this great event, it must be considered as one independent of the common order of nature; for in the usual changes of the sea and land, and the agencies to which they are exposed, nothing analogous occurs, and it must be referred to some power operating in a novel manner in our system. As yet we are not perfectly able to explain the existing economy of things, and our theories of past changes must be more incomplete the more these changes are remote. Placed, as it were, mere atoms upon a point of space, we perceive only a few objects, and a few of their relations, and to these we are obliged to refer in all our reasonings; whilst in the universal series of occurrences, influences may have acted, and may still be acting, of which we have no conception: yet, nevertheless, it is proper that we should reason from the present concerning the past, if we reason with a calm understanding. The strength and correctness of the imagination can only be preserved by exercise; and suppositions, when they are made only the amusements of the imagination, are rather useful than injurious, for they increase the activity of the mind; they accustom it to rapid combinations; and they are only dangerous when they are insulated from facts, when they are mere distempered dreams, or when they are pertinaciously adhered to, and opposed to the conviction of truth. The human mind, deriving all its ideas from the senses, when in a state of healthy exertion, sooner or later uniformly refers to facts; and when hypotheses are used merely as instruments for comparing facts and for ascertaining their minute relations, they promote, in the highest

degree, the efforts of inventive genius, and tend to impress on the understanding the true and unperverted energies of nature."

These miscellaneous specimens of his lectures will enable the reader to form some notion of their style of composition, and to account for the very favourable manner in which they were received. If I appreciate them too highly as literary productions (and it may be so from unavoidable bias); if their merits should be considered by the reader to be overrated,—the conclusion is unavoidable, that the very remarkable impression which they certainly did produce, and that on an enlightened and highly educated, and, I may add, refined audience, must have been owing to the powers of the lecturer as a public speaker. In further illustration, I shall make a few remarks, conveying the impression which they have left on my mind, and recording the manner in which they were conducted. He was always in earnest; and when he amused most, amusement appeared most foreign to his object. His great and first object was to instruct, and, in conjunction with this, maintain the importance and dignity of science; indeed, the latter, and the kindling a taste for scientific pursuits, might rather be considered his main object, and the conveying instruction a secondary one. His lectures were almost invariably written expressly for the occasion, not a repetition of lectures; so that the same audience, year after year, might attend, and never be wearied. He commonly wrote his lecture the day before he delivered it. On this day he generally dined in his own room, and made a light meal on fish. He was always master of his subject; and composed with great rapidity, and with a security of his powers never failing him.

Latterly, he trusted a good deal to notes; and, excepting on particular occasions, wrote little more than the parts which he wished to make most impressive, especially the beginning and termination. It was almost an invariable rule with him, the evening before, to rehearse his lecture in the presence of his assistants, the preparations having been made and every thing in readiness for the experiments; and this he did, not only with a view to the success of the experiments, and the dexterity of his assistants, but also in regard to his own discourse, the effect of which, he knew, depended upon the manner in which it was delivered. He used, I remember, at this recital, to mark the words which required emphasis, and study the effect of intonation; often repeating a passage two or three different times, to witness the difference of effect of variations in the voice. His manner was perfectly natural, animated, and energetic, but not in the least theatrical. In speaking, he never seemed to consider himself as an object of attention; he spoke as if devoted to his subject, and as if his audience were equally devoted to it, and their interest concentrated in it. The impressiveness of his oratory was one of its great charms; in this he consulted only his own taste and feelings; but at the same time, by a considerable portion of his auditors, it must have been received as a compliment to their own taste and feeling, and powers of understanding; and, in giving them credit for acquirements, no doubt many flattered themselves they possessed them, or had a desire excited to attain them. His experiments were devised on the same principle, not of amusing and pleasing, but of illustrating his discourse, and demonstrating either important properties of bodies, or prin-

ciples of the chemical action of bodies; he took great care that they should not appear to have been introduced for show, and to excite merely wonder, even when most brilliant and wonderful: and his eloquence,—the declamation, as it might be called by some, in which he indulged on the beauty and order of nature, in which he ascended from the works to the great Artificer, and from the admirable design every where apparent to the infinite wisdom of the Author of the universe,—his eloquence, I believe, on these topics was so well received, because it was not affected; merely his own strong impressions and feelings embodied in words, and delivered with an earnestness which marked their sincerity.

This account of his style of lecturing is not altogether accordant with Dr. Paris's sentiments respecting it, who damns whilst he praises, and blames whilst he defends. "It was urged (Dr. Paris remarks) by several modern Zoili, that the style was far too florid and imaginative for communicating the plain lessons of truth; that he described objects of natural history by inappropriate imagery; and that violent conceits frequently usurped the place of philosophical definitions. This was the Beotian criticism; the Attic spirits selected other points of attack: they rallied him on the ground of affectation, and whimsically represented him as swayed by a mawkish sensibility, which constantly betrayed him into absurdity."—"There might be some show of justice (Dr. Paris proceeds) in this accusation. The world was not large enough to satisfy the vulgar ambition of the conqueror; but the minutest production of nature afforded ample range for the scrutinising intelligence of the philosopher, and he would consider a particle

of crystal with so delicate a regard for its minute beauties, and expatiate with so tender a tone of interest on its fair proportions, as almost to convey an idea that he bewailed the condition of necessity which for ever allotted it so slender a place in the vast scheme of creation." *

If such had been my brother's style of lecturing, well might it have been condemned: but I deny it *in toto*. Nothing could be more different than *his* style and this imagined by Dr. Paris. Had it been such, who would have had patience with it,—who, but Dr. Paris, could have defended it? Such affectations and puerilities were my brother's utter detestation. Dr. Paris has compared him with Michael Angelo; such criticism would have been just as applicable to Michael Angelo. It was the grand, the striking, the truly poetical, that he delighted in, and delighted to represent,—what impressed him strongly, and which, without affectation, he could express strongly, desirous of exciting a worthy interest in the minds of his audience, as I have already mentioned. The specimens I have given of his lectures will, I believe, bear me out in this statement; and I challenge the production of a single passage, from any lecture of his, answering to faults alleged by Dr. Paris's "Attic spirits."

* Dr. Paris's "Life," &c. p. 92.

CHAPTER IV.

LABORATORY OF THE ROYAL INSTITUTION. — HIS MANNER OF EXPERIMENTING. — HIS NOTICE OF DR. WOLLASTON. — HIS WAY OF LIVING. — ANGLING RELAXATION. — EXTRACT FROM SALMONIA. — RECOLLECTIONS OF HIM. — VISITS HIS FRIENDS IN CORNWALL. — EXCURSION INTO WALES. — NOTICE OF OTHER EXCURSIONS. — ANECDOTE OF HIM, GIVEN BY LADY BROWNRIGG. — RELIGIOUS SENTIMENTS. — EXTRACTS FROM HIS JOURNAL OF A TOUR IN IRELAND. — PARTS OF LETTERS OF HIS RELATING TO IRELAND. — EXTRACTS FROM HIS UNFINISHED SKETCHES OF THE GEOLOGY AND MINERALOGY OF CORNWALL. — SPECIMENS OF HIS POETRY.

One of the principal motives which induced my brother to quit Bristol was the ampler scope he expected to have in the laboratory of the new institution for indulging his passion (for so his love may be called) for research. This was part of the agreement between him and Count Rumford, as is mentioned by my brother in a letter to Mr. Gilbert, published in Dr. Paris's work, in which he says, "The sole and uncontrolled use of the apparatus of the Institution for private experiments" was to be granted to him, with the promise of "any apparatus he might need for new experiments." And I find from his note books, that a few days after his arrival he resumed an experimental inquiry on galvanism, which, some months previously, he had commenced at Clifton.

The laboratory of the Institution I shall briefly sketch, such as I remember it when I first became its inmate, in the winter of 1808, when experimental researches were carried on within its walls with a zeal that it would be difficult to surpass, and were re-

warded with discoveries of more than ordinary brilliancy. The room was spacious, well ventilated, and well lighted from above, and well supplied with water. It was divided into two compartments, nearly of equal dimensions; one the laboratory proper, the other provided with rows of seats to be used as a theatre for the accommodation of the students of practical chemistry. The apparatus most conspicuous and most in use were, a sand bath, for chemical purposes, and for heating the room; a powerful blast furnace; a moveable iron forge, with a double bellows; a blow-pipe apparatus, attached to a table, with double bellows underneath; a large mercurial trough, and two or three water pneumatic troughs, and various galvanic troughs; not to mention gasometers, filtering stands, and the common necessaries of a laboratory of glass or earthen ware, &c.; and not to mention the delicate instruments liable to be injured by acid fumes, which were commonly kept in another room, as air-pumps, balances, &c. In brief, in regard to its equipment and appearance, it was altogether a working laboratory, designed for research: there was no finery in it, or fitting up for display; nothing to attract vulgar admiration; no arrangement of apparatus in orderly disposition for lectures, and scarcely any apparatus solely intended for this purpose. It was, indeed, an almost constant scene of laborious research; and the preparation for the weekly lecture, or lectures, was considered not the most important matter, but rather as an interruption to the ordinary course of experimental investigation. In the laboratory, where my brother spent a great portion of every day that he was in town and at leisure, he was unremittingly engaged in original

experiments; and even in his absence the operations were not suspended: they were continued by his assistants, according to the directions which he had given; and when he returned, he finished the experiment or examined the results. Nothing was left to memory; an entry was made in a large book, kept for the purpose, of all that occurred, written either by himself, or by an assistant from his dictation; not, indeed, in minute detail, for that would have occupied too much time, but briefly, for aiding the memory, and minutely only in regard to weight and measure, and what was most important and characteristic. In his inquiries there was never any mystery or concealment, but the most perfect openness. The register of experiments was left open; he received his friends in the laboratory, and conversed with them on the objects of inquiry in progress; and however intensely engaged, he was always accessible. I can never forget his manner when occupied in his favourite pursuit; his zeal amounted to enthusiasm, which he more or less imparted to those around him. With cheerful voice and countenance, and a hand as ready to manipulate as his mind was quick to contrive, he was indefatigable in his exertions. He was delighted with success, but not discouraged by failure; and he bore failures and accidents in experiments with a patience and forbearance, even when owing to the awkwardness of assistants, which could hardly have been expected from a person of his ardent temperament. And his boldness in experimenting was very remarkable: in the operations of the laboratory danger was very much forgotten, and exposure to danger was an every-day occurrence. Considering the risks run, and the few, if any, precautions taken

against accidents, it is surprising how small a number of injuries were received. The only two serious wounds that I recollect he sustained, were in the hand and eye; the one, from receiving on his hand a quantity of melted potash; the other, from an explosion of a detonating compound. Had his constitution been bad, the use both of hand and eye would probably have been impaired; indeed, the eye ever after retained the mark of the wound inflicted on the transparent cornea, and never perfectly recovered its strength.

Here I must not allow to pass, without comment, some remarks which Dr. Paris makes relative to my brother's manner of conducting his experimental researches. Dr. Paris's words are:—

"It was his habit in the laboratory to carry on several unconnected experiments at the same time, and he would pass from the one to the other without any obvious design or order: upon these occasions he was perfectly reckless of his apparatus; breaking or destroying a part, in order to meet some want of the moment. So rapid were all his movements, that, while a spectator imagined he was merely making preparations for an experiment, he was actually obtaining the results, which were just as accurate as if a much longer time had been expended. With Davy rapidity was power."*

This is a passage for effect, preparatory to a comparison of Dr. Wollaston's and my brother's manner of experimenting, and I have no hesitation in saying that it is very inaccurate. It was not his habit to engage in unconnected experiments; on the contrary,

* Dr. Paris's "Life," &c., p. 96.

he most frequently directed his attention and concentrated his powers on one object. Every experiment was undertaken with a certain design; and if there were several carried on at once, they belonged to one series. To an ignorant spectator, indeed, they might appear to be without order and design, as any series of experiments necessarily must appear to those who are unacquainted with chemical science, or even to those to whom the plan and design of the research has not been developed. His recklessness of apparatus is not justly represented. His manner might sometimes appear reckless to an ignorant person, especially in certain inquiries, in which substances were made to act on gases in retorts, and when to examine the results it was often necessary to break the containing vessel. It is true that he had no hesitation in applying an apparatus to various purposes, for which, perhaps, it was not originally intended, and in making it as useful as possible. For apparatus, independent of utility, he had no respect nor regard. He considered them merely as instruments to be subservient to his designs, and to accomplish his purposes. He was rapid in execution, because his mind was active, and in this mental activity his power consisted.

Of Dr. Paris's comparison of Dr. Wollaston and my brother little need be said. It is a manner of writing which is dangerous, too often indulged in for effect, and tempting exaggeration. Contrasting the two, Dr. Paris remarks, "Every process of the former was regulated with the most scrupulous regard to microscopic accuracy, and conducted with the utmost neatness of detail. It has been already stated," he continues, "with what turbulence and apparent

confusion the experiments of the latter were conducted; and yet each was equally excellent in his style, and, as artists, they have not unaptly been compared to Teniers and Michael Angelo."* I may remark, that when very great care and minuteness were necessary, they were observed by my brother; and when not observed, it was, I believe, because he did not think they were required. He was no more a slave to manner of experimenting than he was to the apparatus he used. Were it necessary, I might mention many instances of minute research, requiring great delicacy and accuracy of manipulation, in which he engaged; as his various galvanic experiments, especially those contained in his first Bakerian Lecture, in which he arrived at very important conclusions, and refuted many errors by scrupulous accuracy of experimenting, and attention to the most minute circumstances; as the whole of the experiments contained in his second Bakerian Lecture on the metallic bases of the fixed alkalies, in which, operating on portions not exceeding in bulk

* Dr. Paris, p. 97.

It may be acceptable to the reader to have my brother's own view of the character of this "illustrious philosopher," as he designates Dr. Wollaston, in a note to Salmonia, written after his friend's decease, when describing how "he applied his pre-eminent acuteness, his science, and his philosophy, to aid the resources and exalt the pleasures of the amusement of angling."

"Wollaston may be compared to Dalton for originality of view, and was far his superior in accuracy. He was an admirable manipulator, steady, cautious, and sure; his judgment was cool; his views sagacious; his inductions made with care, slowly formed, and seldom renounced. He had much of the same spirit of philosophy as Cavendish; but, unlike Cavendish, he applied science to purposes of profit, and for many years sold manufactured platinum. He died very rich. Some accidental annoyances in the medical profession made him, I think, jealous and reserved in the earlier part of his life; but latterly he became far more agreeable and confiding, and was a warm and kind friend, and a pleasant social companion."—*MS. Sketches of Contemporaries.*

pins' heads, he determined, with extraordinary accuracy, the most important properties of these new substances, and the proportions in which they entered into combination; and further, I might mention that difficult and refined inquiry which he carried on with extraordinary patience and minuteness and care, in 1809 and 1810, relative to the apparent metallisation of ammonia, and its absorption by potassium. He himself, in the character which he gives in his "Consolations in Travel" of the chemical philosopher, places prominently amongst his qualities "patience, industry, and neatness in manipulation; and accuracy and minuteness in observing and registering the phenomena which occur," qualities which, he says, are essential. When my brother travelled on the Continent, what was his apparatus? It was on a minute scale, almost as minute as Dr. Wollaston's. In the work last mentioned he remarks, "All the implements absolutely necessary may be carried in a small trunk." Dr. Paris seems to delight in paradoxes. Whilst he calls my brother's manner of manipulating apparently careless and slovenly in the laboratory, he says his style of experimenting in the theatre was "elegant," and that it was "perhaps impossible to imagine a greater contrast," which he endeavours to explain by observing, that "in one case he was communicating knowledge, and in the other obtaining it;" a reason forcible and just, were the conditions changed, inasmuch as to obtain knowledge by experimental investigation a much greater degree of accuracy and minuteness is necessary than for the purpose of communicating this knowledge when once obtained. Appearances in these things are most deceptive: in the theatre experiments are made for

illustration, and are generally of a simple kind, and easily comprehended, and the minds of the audience are prepared by the lecturer to follow and understand them. In the laboratory, on the contrary, this aid is wanting when most necessary; and, in consequence, operations, as already observed, of a very accurate kind, and carried on with a perfect design, may appear confused to the uninstructed, or to the uninitiated.

Of my brother's mode of living, and of some of his habits whilst he was at the Royal Institution, I shall also speak from my own knowledge. As long as he was a bachelor, he was perfectly satisfied with his rooms at the Institution, in which he considered chiefly utility, and thought little of comfort, and much less of luxury. He showed great carelessness in all that related to their furniture and appearance. These were to him matter of indifference. I believe the furniture was merely what belonged to them when he first took possession, and that he made no addition to them or alteration. The only thing ornamental that I recollect in his sitting-room was an elegant little porcelain Venus, which was a present to him from his early friend Mr. Wedgewood; it was of his manufacture, and an admirable specimen of art. Letters and papers he very seldom arranged, and his rooms were commonly littered with them. Occasionally they were collected and thrown together in a large cupboard. I remember once his commissioning me to look over this great collection, and to burn such as appeared of no interest. Amongst them were very many letters of the highest compliment, and some of kind advice from anonymous writers, or declared friends, pointing out, on his

commencing lecturing at the Institution, what was considered faulty in his manner, and even in his pronunciation; but they were most commonly of a laudatory kind; and of this kind were several copies of verses, written in female hands, showing that he had excited no ordinary interest in their breasts, and that their admiration was of a very exalted kind. Yet all the praise that was bestowed, all the delicious flattery which he received, and which might have spoilt the best disposition, and seduced from the path of exertion to luxurious repose, or dissipation in the circles of fashion, seemed to have been either wasted on his mind, and to have made no impression, or to have acted as a spur to continued exertion; and he never laboured harder, or exerted himself more successfully, than at the time he received most court, and apparently indulged most in the pleasures of luxurious society.

In the disposal of his time, he was far from systematic, directed rather by circumstances than guided by any precise rules. When in town, he generally entered the laboratory after breakfast, about ten or eleven o'clock, and, if uninterrupted, remained there till three or four. Dr. Paris, in describing the manner in which he was occupied, indulges in some exaggeration, stating how he worked in the laboratory till his dinner hour was past; how he returned to his labours in the evening, and commonly continued at them till three or four o'clock in the morning, and yet was risen not unfrequently before the servants. According to Dr. Paris's statement, "The greatest of all his wants was time, and the expedients by which he economised it often placed him in very ridiculous situations, and gave rise to habits of a most

eccentric description. Driven to an extremity, he would in haste put on fresh linen without removing that which was underneath; and, singular as the fact may appear, he has been known, after the fashion of the grave-digger in Hamlet, to wear no less than five shirts and as many pair of stockings at the same time. Exclamations of surprise very frequently escaped from his friends at the rapid manner in which he increased and declined in corpulence."* In this description there is much exaggeration, either in consequence of erroneous information, or from writing for effect. Instead of returning to the laboratory after dinner, and working there till a late hour, and resuming his labours after three or four hours' sleep, it was very unusual for my brother to revisit it after he had dressed for dinner, and before breakfast I do not believe he ever entered its precincts. He was never, to the best of my knowledge, in the habit of abridging greatly his hours of rest, which were commonly seven or eight. The particulars respecting his linen and toilet for dinner are too minute to be correct. The account of his wearing five shirts put on successively for want of time to make a change, was founded, perhaps, on his habit of wearing two shirts for the sake of warmth in cold weather; a custom which, as long as I knew him, he indulged in. Fashion in dress and appearance was of trifling consideration to him; he consulted rather ease and convenience.

His way of living during this period was of the most easy kind. Except when preparing a lecture, as already mentioned, he seldom dined in his apartments at the Institution: his invitations to dinner

* Life, p. 184.

amongst his friends were so numerous that he was, or might have been, constantly engaged; and after dinner he was much in the habit of attending evening parties, devoting the evening to amusement; so that, to the mere frequenters of such parties, he must have appeared a votary of fashion rather than of science. When his pursuits did not keep him in town, he often made short visits to friends residing in the neighbourhood of London, or went to some trout stream, of which there are so many good ones within twenty or thirty miles of the metropolis, and breathed the fresh air by the river side, and enjoyed the country and his favourite exercise and amusement of fishing together.* In his "Salmonia, or Days of Fly-fishing," written in illness, during the latter part of his life, with what delight does he recall these river scenes! Speaking of angling in its poetical relations, with genuine poetical feeling, he says, "It carries us into the most wild and beautiful scenery of nature; amongst the mountain lakes, and the clear and lovely streams that gush from the higher ranges of elevated hills, or that make their way through the cavities of calcareous strata. How delightful in the early spring, after the dull and tedious time of winter, when the frosts disappear, and the sunshine warms the earth and waters, to wander forth by some clear stream, to see the leaf bursting from the purple bud, to scent the odours of the bank perfumed by the violet, and enamelled, as

* If confined in London longer than usual, and deprived of his favourite amusement of angling, he not unfrequently, as a relaxation, would turn to his fishing tackle, and look over his fly-book and assort the gaudy materials for making flies; and I very well recollect the effect on his mind was always refreshing.

it were, with the primrose and the daisy ; to wander upon the fresh turf below the shade of trees, whose bright blossoms are filled with the music of the bee, and on the surface of the waters to view the gaudy flies sparkling like animated gems in the sunbeams, whilst the bright and beautiful trout is watching them from below ; to hear the twittering of the water-birds, who, alarmed at your approach, rapidly hide themselves beneath the flowers and leaves of the water-lily ; and, as the season advances, to find all these objects changed for others of the same kind, but better and brighter, till the swallow and the trout contend, as it were, for the gaudy May-fly, and till, in pursuing your amusement in the calm and balmy evening, you are serenaded by the songs of the cheerful thrush and melodious nightingale, performing the offices of paternal love, in thickets ornamented with the rose and woodbine." And during the vacations, when he had some months' leisure, he commonly made longer excursions. At different times he explored most parts of Great Britain, including even the distant parts of Scotland, and the Hebrides; and more than once he travelled through Ireland. His object in these journeys, as will appear from a journal of one of them, from which I shall have occasion to make some extracts, was partly amusement and the acquiring of general information, and partly the study of the geological structure of the kingdom, and the phenomena of rock-formations in relation to geology as a science, and partly the collecting of agricultural knowledge. He made sketches of remarkable features of rock-scenery, of peculiarities in their appearance ; and he collected specimens of rocks, and minerals, and soils, which were deposited on his

return in the museum of the Institution, or in its laboratory for examination. When he lectured either on the subject of geology or agriculture, he availed himself of them, and of paintings made from his sketches, which were not less serviceable in illustrating his descriptions and doctrines than the specimens of rocks and minerals themselves. His power of extracting information was great, and it was constantly employed in these excursions, and I believe gave a strong idea of talent and capacity to comparatively uninstructed men. I recollect going through a mine, when I was a boy, with an intelligent Cornish miner, who, two or three years before, had accompanied my brother; he said, he had never before met with a person so inquisitive, and who asked him so many searching questions; and, from the manner in which the miner made the remark, he was evidently surprised as well as pleased at the deep interest he took in mining affairs.

Thus spending his time, admired and highly popular as a lecturer, courted in society for his genius and agreeable conversation, and in the highest estimation as a man of science, with a happy sanguine disposition, and a capacity for enjoyment equal to his ample means,—he possessed an uncommon degree of happiness, a larger proportion than any one has a right to expect, and a far greater than the majority of mankind ever enjoy. I have, even now, after the lapse of five and twenty years, a very pleasing and vivid recollection of his cheerful and buoyant spirit, as well as of his extraordinary activity and energy. When I resided with him at the Institution, between 1808 and 1811, my bedroom adjoined his, and our beds were only separated by a wainscot

partition. In going to bed, and rising, and sometimes in the dead of night, I used to hear him, in a loud voice, reciting favourite passages in prose or verse, or declaiming some composition of his own, or humming some angler's song.

This, as a general account, may suffice, of this period of his life; I shall now proceed to give some details respecting it during the first six years he was at the Institution.

The earliest leisure he could avail himself of, in 1801, after the conclusion of the session of the Royal Institution, he devoted to visiting his friends and family in the west of England, first at Clifton, and afterwards at Penzance. In this excursion he was accompanied by Mr. Underwood, who has furnished Dr. Paris with some particulars of the tour not uninteresting, though not in all respects accurate. The inaccurate part is the ludicrous story of the offended landlady of the inn at Mullion, given for the purpose of displaying my brother's "gastronomic propensity," which, according to Mr. Coulson, who was one of the party, is merely a story. The particulars which are interesting are those descriptive of him giving way to his feelings of love and admiration of Nature, on revisiting the scenes of his youth, and the grand and beautiful features of the Mounts Bay, the shores of which they completely explored. The next autumn, that of 1802, he made an excursion into Derbyshire and Wales; in the latter country accompanied by his friend Mr. Purkis, whose account of it, written with a very friendly feeling, and in a lively manner, Dr. Paris has inserted in his work. I shall limit myself to one extract from it: —

"We visited (says Mr. Purkis) every place possessing any remains of antiquity, any curious productions of nature or art, and every spot distinguished by romantic and picturesque scenery. Our friend's diversified talents, with his knowledge of geology and natural history in general, rendered him a most delightful companion in a tour of this description. Every mountain we beheld, and every river we crossed, afforded a fruitful theme for his scientific remarks. The form and position of the mountain, with the several strata of which it was composed, always procured for me information as to its character and classification; and every bridge we crossed, invariably occasioned a temporary halt, with some appropriate observations on the productions of the river and on the diversion of angling." *

During this tour he wrote the following letter to my mother: —

"Sept. 1., Bala, in North Wales.

"My dear Mother,

"You received a letter from me dated Buxton, or you ought to have received it. Since that letter was written, I have been at Matlock. I passed through Macclesfield, Manchester, and Chester; and I am now rambling through North Wales. This country, in point of beauty and grandeur, is the first that I have seen; and being a real lover of beauty, and of grandeur, I have been truly enraptured with the various scenes that have been presented to me.

"I have a friend with me; and we propose to traverse the whole of the principality, from Conway to

* "Life," by Dr. Paris, p. 161.

Chepstow, and to return to London by way of Bath and Bristol. I shall write to you as soon as I can reach London; and I should take it very kind if you would address a letter for me to the care of 'J. King, Esq., Dowrie Square, Bristol.' I am anxious to hear how you are, and it is almost five weeks since I received your last letter. You must write immediately, for I shall be in London before a fortnight is expired.

"The man who attends the inn here is almost a Cornishman: he was one of the Merionethshire militia*; and talks to me of every body in Penzance. Wishing you health and happiness, and blessings of every kind, I am, with love to my sisters and John,

"Your very affectionate Son,

"H. DAVY."

During the summer and autumn of 1803, I cannot find that he went any great distance from London. He was then much occupied in chemical researches connected with agriculture, and he spent three weeks with the enlightened President of the Board of Agriculture, the late Lord Sheffield.

The following year, during the fine season, he visited Scotland for the first time, and the Western Islands, and passed some time in Somersetshire; but of neither of these excursions have I been able to obtain any particulars. The former is merely alluded to in a letter to my mother on his return: —

"London, Sept. 3. 1804.

"MY DEAR MOTHER,

"I arrived this morning, safe and well, from my expedition to the North. My journey has been long,

* This regiment had been quartered in Penzance previously.

but very pleasant; and I have brought back with me a stock of health, and of information for the labours of the coming season.

"I hope you and all my friends are quite well; and that John is proceeding in improvement, in stature, and in goodness of disposition; and that Kitty is not the less pleased with the quiet of Penzance, after having seen the splendour of London. Pray remember me to her with brotherly affection, and with all duty to my aunt and uncle Sampson, and my aunt and uncle Millet.

"You will read in the papers constant alarms concerning invasion, but be assured that no invasion will take place at this time; it is the most unfavourable moment for Buonaparte. The imperial diadem hangs over his head by a slender thread, which the slightest reverse of fortune would break; and he will not tempt his fate by the risk of a failure in his plans till he shall be more securely seated in his blood-stained throne.

"There is no news at present in town worth mentioning. I shall be very glad to hear from you of Penzance, for it is very long since I have enjoyed the pleasure of a letter.

"I am, my dear Mother,

"Your most affectionate Son,

"H. Davy."

In 1805, in the summer, after he had delivered his first course of lectures on geology, he made a journey to the north of Ireland, for the purpose of examining the extraordinary basaltic formation of that coast;

and in the autumn he accompanied his friend Mr. (afterwards Sir Thomas) Bernard into Cornwall.

During his Irish excursion he formed the acquaintance, which he ever afterwards highly valued, of the late excellent Bishop of Raphoe, and of his sister, Lady Brownrigg. And I have been favoured by her Ladyship with some account of him at this time, very descriptive of his appearance and manner, which I shall give in her own words: —

"I was very young," Lady Brownrigg writes, "when I had first the pleasure of seeing your highly gifted brother. We had been invited (I say *we*, for I was then with the Bishop of Raphoe) by Dr. Richardson to go to his cottage at Portrush, 'to meet the famous Mr. Davy.' We arrived a short time before dinner. In passing through a room we saw a youth, as he appeared, who had come in from fishing, and who, with a little note-book, was seated in a window-seat, having left a bag, rod, &c. on the ground. He was very intent upon this little book, and we passed through unnoticed. We shook hands with our host and hostess, and prepared for dinner. When I went into the drawing-room, under some little awe of this great philosopher, annexing to such a character at least the idea of an elderly grave gentleman, not, perhaps, with so large a wig as Dr. Parr, or so sententious a manner as Dr. Johnson, — but certainly I never calculated on being introduced to the identical youth, with a little brown head, like a boy, that we had seen with his book, and who, when I came into the drawing-room, was in the most animated manner recounting an adventure on the Causeway which had entertained him, and, from

his manner of telling it, was causing loud laughing in the whole room. The evening passed very agreeably: my brother played chess with Sir Humphry; but after supper a very interesting occurrence took place. A poor unfortunate gentleman, who exemplified that 'a little learning is a dangerous thing,' had thought to show his wit and wisdom in being a professed sceptic, and had volunteered a visit to Dr. Richardson, in order to be made known to Mr. Davy, anticipating a triumph over the two divines, when he had the powerful aid of the great philosopher to overthrow the Christian religion. Therefore, as soon as we ladies had retired, this disciple of Voltaire and the rest of the Encyclopedists openly began, and was elated by the silent and deep attention with which the philosopher listened to him; while my irritable friend, Dr. Richardson, exhibited great symptoms of annoyance: however, all the forms of attack from this *esprit fort* were poured into the ears of your brother. At last he paused, full of triumphant expectation, when, to the inexpressible delight of my brother, in the finest tone of eloquence, and with a fervour of piety, your delightful brother defended Christianity in such a manner that, as the Bishop said, the effect upon him was such that he *stood up*, feeling, for the first time, that impulse which made the congregation all rise at some splendid burst of religious fervour in a sermon of Bourdaloue or Massillon. Your brother, when he had completely put down his opponent, turned in the prettiest manner to the two clergymen, and apologised for having 'taken up the weapons which would have been so much more ably wielded in their hands.' They finished their wine and water, and parted for the night. At break-

fast our deistical friend did not appear. He had actually skulked off to his home, some forty Irish miles from this memorable scene."

This anecdote from Lady Brownrigg brings to my recollection that about this time, as I have been well informed, some of his powerful friends, especially the Bishop of Durham, and Sir Thomas Bernard, were desirous that he should enter the Church, with the persuasion that his eloquence might be of efficient service in the cause of religion, and holding out to him the brightest prospects of preferment. That he declined these offers I need not say. He contented himself with giving his aid in the cause in connection with science, as is expressed in the following letter to Sir Thomas Bernard, which was published in a newspaper of the day, prefaced by some good remarks on the part of the editor on the unfortunate and melancholy disunion between science and religion, which had taken place in France: —

"Royal Institution.

"My dear Sir,

"Many thanks for your kind letter, and for the interest you take in my public labours. I am never more delighted than when I am able to deduce any moral and religious conclusions from philosophical truths. Science is valuable for many reasons; but there is nothing that gives it so high and dignified a character, as the means which it affords of interpreting the works of nature, so as to unfold the wisdom and glory of the Creator. Be assured, my dear Sir, that I shall lose no opportunity of making those deductions which awaken devotional feelings, and connect the natural with the moral sense. And I hope

my claims to your approbation, and to the approbation of men who, like you, combine pious sentiments with noble and enlightened views, will not diminish, for it is very grateful to me.

"I am, dear Sir,

"With the most unfeigned respect,

"H. Davy."

Sentiments of this kind, both in public and private, on suitable occasions, he appears to have had a pleasure in expressing. In the specimens of his lectures already given, instances of them occur; and, later in life, he still more indulged in them. Lady Brownrigg, in recording the preceding anecdote, refers to his "Salmonia," to an eloquent passage, in which he gives his idea of the value of religious belief: —

"I envy no quality of the mind or intellect in others, be it genius, power, wit, or fancy; but if I could choose what would be most delightful, and, I believe, most useful to me, I should prefer a firm religious belief to every other blessing: for it makes life a discipline of goodness; creates new hopes when all earthly hopes vanish, and throws over the decay, the destruction of existence, the most gorgeous of all lights; awakens life even in death, and from corruption and decay calls up beauty and divinity; makes an instrument of torture and of shame the ladder of ascent to Paradise; and, far above all combinations of earthly hopes, calls up the most delightful visions of palms and amaranths — the gardens of the blest, the security of everlasting joys, where the sensualist and the sceptic view only gloom, decay, annihilation, and despair."

In the early summer of 1806, he again went to Ireland, and visited some of the most interesting parts of that country. I shall insert a considerable portion of the journal which he kept during the tour, as it shows the objects for which he travelled, and the systematic manner in which he observed: and for another reason, as it conveys the impressions made on his mind by the country and people in districts in many respects peculiar, and out of the track of ordinary tourists. The reader should keep in recollection, that the journal was intended solely for his own use; that it was never copied by the author, or even looked over for correction; and in brief, that it is composed merely of rough notes, some of which, in consequence of the haste in which they were written, it is difficult to decipher. The journal is a fragment, and commences at Limerick:—

"Limerick, June 27.

"1. The journey from Rathkeal to Limerick, without many objects of interest. Small hills, without wood; plains covered with bog for many miles. Adare is the first place calculated to arrest the attention of the traveller. Here is wood, fine trees, and some monastic buildings beautiful in their ruins. The architecture, where it retains its characteristics, Gothic; the walls covered with ivy: a scene denoting ancient splendour, whilst the cabins which surround the walls tell a tale of existing wretchedness.

"Within four miles of Limerick, a mountain scene is developed. The Keeper chain to the east, the Clare hills to the north; their forms smooth and generally rounded, and the most lengthened inclination to the west.

"*Limerick.*— A large well-built city. The Shannon, a fine river; but, though affected by the tide, certainly inferior in size (perhaps even in the quantity of water it sends down) to the Thames and the Severn, at equal distances from the sea.

"Marks of improvement.—Good buildings rising; a handsome race of people, and more pretty young women than I have seen since our departure from London; a fine fall of the Shannon, when the tide is down; and a river about a mile above it, where salmon are caught in abundance. Limerick might be imagined an English town by those who had no dealing with the keepers of the inns and of livery stables. No beautiful or grand scenery about this city. The banks of the Shannon bare, or but little wooded; and no remarkable character in the river, if the extreme clearness and purity of the water be excepted. From Limerick to Nenagh, a road through a cultivated country. Views from the Shannon, and some fine effects from the Keeper mountains.

"2. Geology of Limerick, and the mountains bordering upon it:—Sandstone schist and sandstone occur near Rathkeal, and shell limestone is abundant on all the road from Killarney to Limerick. Several quarries have been opened. The character of the rock is distinct; much mechanical deposit and little crystalline matter. The colour dark brown, grey, or black. Coal-blend occurs between Killarney and Abbey Feale, probably beneath the sandstone slate. The limestone inclined very little. The strata numerous and parallel; the upper exceedingly broken and decomposed, and the dip, where it could be distinctly perceived, to the south. The shells more abundant in the upper strata.

"These secondary strata probably thrown out of their horizontal position at the same time with the elder strata. Like the elder strata of Kerry, they are often curved. The curvature of the shell limestone distinct in the road to Abbey Feale, but not upon so great a scale as at Ross Island.

"The limestone about Limerick shell-rock, and probably in parallel layers. The surrounding mountains afford the same substance, with sandstone and slate and pebble-stone; probably the slate lowest, then the pebble-stone, then the limestone.

"The Keeper range of mountains, from the smoothness of their outline, and from the detached stones, are probably of similar constitution; that worked for the lead mines called Silver Mines afforded, on examination, similar facts. A few detached stones of granite and syenite on the side of this mountain. A miner told us such occurred in the Keeper; but, as the greatest part of this mountain is grit and limestone, I suspect he has mistaken pebble-stone for primary rock, and that the syenite and granite are from the mountains of Kildare or Carlin. Amongst the line of mountains to the east of Nenagh, is a mountain most singularly indented, called the 'Devil's Bit,' and traditionally said to be a road made for the devil and his goats. It is a great limestone rock (i. e. I am told so). The appearance is probably owing to a sudden sinking of a great portion of a parallel stratum, and the rock, I conceive, must be shell rock. The fact is the more singular, as the surrounding mountains are gently rounded, but this presents only straight lines.

"3. Land well cultivated for Ireland; much pasture, but no irrigation; not much liming; the soil very calcarious; wheat and barley, but little flax.

"4. The lower classes poorly clad, and nearly as miserable as those of Cork. No marks of that enthusiasm of character which sometimes occurs in Ireland. Idleness without thought, and the old association of ignorance and impudence. Miserable articles of Irish manufacture, spoken of by their venders as superlative. The Limerick hooks and flies altogether fallen off, very bad, and very expensive; yet every paltry fisherman considers himself as the best fly-tyer 'in Limerick, in Dublin, in all Ireland, ay, and in England too—ay, and in the whole world'—having 'the best colours, making the *naitest* hook, and having the quickest eye and the naitest hand.'

"The shops well furnished with English manufactures. All comforts, all luxuries, all spirit of improvement, all that makes Ireland important and respectable, are either of foreign growth or of foreign education. The great vice of the people is want of perseverance: nothing is finished; they begin grandly and magnificently, but complete very little. In mining, they build machinery before they have discovered a vein; in the fisheries, they erect their cellars before they have purchased nets; and they build magnificent stables, which they intend for their studs, but which they are themselves obliged to inhabit. Foresight and prudence are unknown.

"*Edgeworth Town.*—First aspect of the country between Nenagh and Edgeworth Town flat, bare, and without any objects of beauty. The course of the Shannon is through a flat country, its banks bare and reedy; its current slow; sometimes deep and still, and confined within shores of one hundred yards, at other times expanded into lakes, with islands. No mountains; hills so rare, that a woman at Athlone, recom-

mending us to take four horses on account of the *hills*, said they were 'terrible hills, very high, as high, ay, and higher too, than the house,' which was an exceedingly low edifice of two stories. The Shannon at Portumna is deep, but rapidly spreads out in its course into a great loch. At Banagher it is rapid below the bridge, and at Athlone still more rapid, and not more than fifty yards over. The little river Inny runs by Ballinachur. Here are hills, but no wood, and bog or grass land, with some arable. Flax and barley, and a little wheat.

"The country about Edgeworth Town flat, but an amphitheatre of hills surrounding the plain. None of them very high, probably all less than 1000 feet. One hill, the hill of Ardar, we ascended, and saw a great extent of ground: the quiet Shannon rolling sleepily and slowly through green meadows and brown bogs, to the south; to the west, a great range of very distant mountains; to the north the hills of Westmeath, low and rounded; to the east, fog, where, in a clear day, we might have seen the mountains of Wicklow.

"2. Limestone, sandstone, and puddingstone, in various associations.

"3. Except the moral and intellectual paradise of the author of 'Castle Rackrent,' nothing worthy of observation.

"4. The county of Westmeath and that of Longford abound in small lakes, which are surrounded by bogs; and in the shores of them, in dry seasons, the horns and bones of deer are discovered in great abundance. This country, now so bare, was anciently an immense forest; and it is an object which might employ speculation as worthily as many other objects,

whether the great change was owing to the slow operations of nature, decay, or to some great convulsion or inundation.

"Donegal, July 17.

"1. Aspect of the country from Edgeworth Town to Belturbet, without any marked traits of beauty; some hills to the south possessing a varied outline, but a general want of wood; green and cultivated fields, bogs and heath land.

"From Belturbet to Enniskillen an exceedingly beautiful country. The Erne appears, at Belturbet, immediately in the town, a rapid torrent, but becoming a lake above and below. The access to Loch Erne is through rounded hills, green with pasture; few trees. From the top of the hill, about eight miles from Belturbet, the lake appears a noble expanse of water, with many wooded islands. A green and cultivated hill, of most graceful form, the principal near object, and some blue mountains in the background, tabular and smooth; a view of great extent, soft and quiet, without rudeness of form or strong contrast of colouring, yet impressive from its magnitude, from the variety of land and water, and from the beauty of cultivation. A number of lakes of various sizes, few exceeding two miles in circumference, border the upper part of Loch Erne, and pour their waters into the Upper Erne; but the banks of most of them are boggy. There is no rock scenery, and few trees. At Enniskillen the Upper Loch Erne is joined to the Lower by two streams crossed by bridges, and the town stands in the island formed by them. The road from Enniskillen to Ballyshannon is exceedingly beautiful. Views of Loch Erne, studded with green

islands, and bounded by blue mountains, to the east; on the west and south, hills covered in some parts with wood, and exhibiting in most parts trees just beginning to throw out young shoots from their lopped trunks. About Church Hill, to the north, a small lake, surrounded by very grand mountain scenery, indented rocks, disposed in some parts in horizontal layers, forming the western boundary; green mountains, presenting here and there blue and yellow cliffs; and in the distance a great surface of bare rock, not less than 700 or 800 feet above the lake. The mountains on the south extending from the Upper Loch Erne to Sligo, all similar in form, and presenting immense layers of rocks, having bright green slopes at their bases, and immense gullies cut from the top to the bottom. Their outline is made up of straight and jagged lines; their side often nearly perpendicular, and the highest probably considerably above 2000 feet. The first view of Loch Erne is at about five miles from Church Hill. Here the mountain cliffs of Leitrim form a grand outline on the south; and the mountains of Fermanagh, composed of irregular masses of bright brown rock, covered with heath, and at the feet green with grass, appear to the north and east, rising boldly out of the lake's wooded promontories; hills repose beyond them, and the great expanse of water is broken by an immense number of islands, all of soft and curved forms, and for the most part finely wooded; in the northern distance, the blue mountains of Fermanagh, and further west, those of Donegal.

"The Erne runs rapidly over dark layers of rock into the sea at Ballyshannon; its banks are but little wooded, but it is a noble river, a succession of small

cataracts; and its last and greatest fall is a wild and sublime scene. The river precipitates itself over jagged, broken, stratified rocks, into the Atlantic; white foam, and brown water, and black rock, and the blue sea, are the prime objects: the scene is the more impressive from the simplicity of its parts. From the hill above Ballyshannon appear, to the south, the hills of Sligo and of Leitrim, bold and fantastic in form; Benvallen, a pyramidical mountain, appearing almost immediately above the town, and yet it is said to be twenty miles distant: Cape Tillen, to the west, a noble mass of mountain, grand and indistinct; the hills to the north of very fine outlines, and colouring bright brown, bare, and apparently producing nothing but moss.

"The road from Ballyshannon to Donegal over green hills; no trees. The bare rocks and mountains having their summits sometimes disclosed, and sometimes hidden in mist, in the background. The river Esk, a fine mountain torrent; but without wood on its banks, aud having nothing to recommend it but the wildness of its surrounding scenery.

"2. People more civilised than in the midland counties, or in Kerry; better dressed, and more beauty of person. Protestants becoming more numerous as we advanced further north; still considerable religious feuds. We passed from Belturbet to Enniskillen on the 12th of July, the day of King William's triumph, and we heard and saw much riot; processions of men with the orange lily in their hats, women wearing this flower as a nosegay. The liberty of wearing it interdicted to the Catholics; a sign by which the Orangemen are still known. At night there is generally a battle between the two par-

ties. The Catholic soldiers at Enniskillen, the Limerick militia, did not fire on this day, but the Protestant regiments always do. Ballyshannon is a truly Irish town — high houses, good in exterior, wretched internally; peats stopping up the windows; broken glass; no sashes to be found.

"3. Course of crops.—Potatoes, oats, barley: this about Loch Erne. Further north a more enlightened system. At Ramelton, in Donegal, potatoes, barley, oats, flax. After seven years, usually a fallow; then grass seed is sown, and three years taken in grass. Manure with the potatoes, never with the flax. Shell-sand used, particularly after fallow. Flax the staple commodity of the country.

"*Geology of Fermanagh, Cavan, Leitrim, Donegal.*

"In Cavan, about Ballinaght, a granitic schistose country. The granite associated with grawaké schist and porphyry, and probably of the first family of secondary rock. The schist, composed of compact felspar and chlorite, with a little mica; the porphyry having a base of compact felspar, and much decomposed, and where decomposed white. Beyond Cavan the secondary strata again occur, and continue to Ballyshannon, where the first micaceous schist in the west and north of Ireland occurs, at least as far as our knowledge extends. Limestone and sandstone at Belturbet; limestone dipping to the west, and abounding in shells and coral of different kinds; limestone occupying the greatest part of the subsoil in the road to Enniskillen, and an immense number of layers, in general parallel to the horizon. At Church Hill, cliffs of a limestone of considerable consolidation. The mountains of Leitrim composed of

parallel layers of limestone and sandstone; basaltic bolder stones, probably from dykes.

"At Ballyshannon the Erne falls over limestone rocks, and a fine crystallised magnesian limestone occupies the lowest strata on the banks of the Erne; and this limestone contains rhomboidal spathose crystals, and quartz crystals, in great abundance; and above it is a limestone full of corals, alternating with a carbonaceous shale, but no coal visible. Coal will probably be found in abundance in the lowest part of the Leitrim mountains, as the strata are of the carboniferous family.

"The high mountains of Donegal are, probably, all micaceous schist, or granite, or sienite, at least in this part.

"In the mountain road through the Barnesmore-gap, high mountains of granite, with comparatively little mica, constratified and massy in formation. Lower micaceous schist, of beautiful varieties; a number of species of gneiss; tumblers of trap and syenite; a few quartz veins in the granite, and some veins of quartz and of calcareous spar in the gneiss above Donegal: no chlorite, metalliferous indications in these mountains."

"Donegal, July 19.

"*Ramelton.* — Road from Ballyshannon to Donegal exceedingly wild; rude mountains to the north and west; green hills around the course of road; views of Cape Tillen, and of the mountain capes stretching into the Atlantic, and the mountains of Leitrim south, stratified, and presenting a striking contrast to the rude massive rocks of Donegal.

"At Ballybofey, the river Finn, a large mountain

stream, at this time brown from floods; wooded hills on the west; bare brown curved hills on the east and north-east. From Ballibofey to Litterkenny, a very wild road; a great chain of mountains to the north and north-west; the Arrigle and Muckrsh. The summit of Arrigle peaked, and rising acutely pyramidical; that of Muckrsh tabular. The valleys wild, and but little cultivated; very few trees; grey rock, heath, and the sides of gullies covered with lively green herbage.

"From Ballybofey to Ramelton, a very fine and impressive assemblage of scenery. Loch Swilly, a fine expanse of salt water, bounded in front by green habitable hills; a few groups of trees on the very edge of the water; in the distance high and wild mountains; two peculiar, marked in outline and height, tabular and rounded; the most northern, Ossian's Mount. On the west and north, magnificent views of the Arrigle and Muckrsh chain, indistinct, blue, rising amongst the clouds, which are rolling about their sides and summits; irregular craggy hills, chiefly bare rocks, below them.

"Ramelton, seated on the banks of a beautiful river, immediately discharging itself into Loch Swilly; trees on the banks of the water; distant mountains above, and parts of the loch, with its beautiful boundaries, visible from all the streets of the village.

"2. The best race of people that has appeared in the course of the journey; civility, with independence of spirit; no marks of the broken reed of rebellion; no humility nor crouching, but much dignity and simplicity; yet the potatoe grows even amongst the mountains of the Finns, and the unquiet and uncertain spirit now and then breaks forth.

I witnessed the humours of a crowd at Ramelton, assembled after having seen a pony race. A great number of men and women jostled together in the narrow streets of a little town, without any other object than that of pushing each other; every room in every house filled with people, enjoying whisky and tobacco; beggars, wherever there was a standing, or a sitting, or a lying place; a number of drunken horse and foot passengers; much finery of dress, but a number of persons who seemed rather to have wished to appear magnificent than to know how to produce the effect; a profusion of ribands and of white linens; not much beauty of person. A great fight took place after the fair (an event that is always hoped for, and expected), and a number of heads were broken, and much blood, inflamed by whisky, shed, but no lives absolutely lost; one man was 'twice killed' by another, knocked down, and the head twice cut. He was a Litterkenny boy, and had offended the oppressing hero, by saying, 'Ay! and is not the boy of Latterkenny as good as the Ramelton boy, at cutting a bog or at heaving the peat?' Many traditional stories of the giant race of the Finns, and their chieftain, Finmacoul; and Gaelic songs are said to be remembered and recited by the old men in the wild glens of Muckrsh and Arrigle.

"3. *Geology.*—Granite and micaceous schist, and a great variety of syenites about Ballybofey. The inclination of the micaceous schist appeared to me to be uniformly to the north. Limestone about a mile from Ballybofey; carbonate of lime, with much mica, stratified and directed to the north; alternate layers, in the principal quarry, of a compact siliceous rock and crystallised carbonate of lime, and, the car-

bonate of lime having been washed out at the surface, the rock appears ribbed: much curvature, both of the siliceous rock and the marble veins of quartz and of calcareous spar cutting the limestone, and specks of copper and much pyrites in the veins; lower is a more compact marble; the upper marble is splintering in fracture, but this is nearer Carrara marble: this, probably, a great dyke of the same formation as the Killarney marble, filling a chasm in the micaceous schist.

"From Ballybofey to Ramelton, a similar constitution of country, similar inclination, curvature of strata, and immediately by Loch Swilly, great abundance of a micaceous schist, principally composed of quartz.

"In the mountains above Loch Foyle, and by Loch Salt, marble of elder formation, and a rock approaching very nearly to serpentine in its character, but composed of hornblende, felspar, and a little chlorite. The high mountains about Loch Salt, syenite and quartz rock; no regular inclination, but a distinct stratification, and much disturbance and curvature: the limestone beds inclined to the south.

"In the general arrangement about Loch Swilly, the micaceous schist occupies the lowest position; above this is a stratified rock, principally consisting of marble, with a little mica, and exceedingly incurvated; and upon these occur the beds of limestone, which, in several instances, are in absolute contact and union with micaceous schist, and contain mica in abundance; at the top of all, syenite of different kinds: the felspar and mica exceedingly white, and very decomposable; and quartz rocks crystalline, and having the greasy fracture.

"Muckrsh, said to be composed of quartz-rock. The quartzose sand belonging to it has probably resulted from the decomposition of a compound rock of quartz and felspar.

"The immense proportion of quartz in the mountains of this district is a fact which can hardly be explained by any application, however forced, of the Huttonian theory. Pressure cannot interfere where the material is simple, and where no elastic matter is present; and to suppose any terrene solvent, which has afterwards been separated, will not coincide with the known laws of chemical affinity.

"Sunday, July 22.

"1. The morning of this day I spent in a ride to the mountain district of Donegal. From Ramelton to Nilmacrenan, wildness in the fore-ground, and in the back-ground bogs, and bare rocks in the valley. The sides of the hills only cultivated, and the summits partly coloured, brown heath, and grey or white rock.

"At Loch Salt, three miles from Nilmacrenan, a grand view. The Atlantic to the north-west, with a variety of salt-water lochs washing the feet of bleak mountains; fresh-water lochs nearer, in the cavities of the mountains. Amongst these, Loch Salt wonderfully magnificent; breasted by a mountain to the east, at least a thousand feet high, and principally composed of rocks so white as to seem covered with snow; to the west, green hills with curved rocks, and a singular assemblage of decomposed and water-worn stones; and to the south an almost perpendicular precipice.

"From the summit of the mountain above Loch

Salt, the wildest scene in Ireland, Muckrsh and Arigle, having their summits peeping above the clouds; distant, yet only so distant that the great gullies of Arigle and its yellow colouring were visible, and the dark heath of Muckrsh, and its white seams of sand: between the intermediate mountains, precipices of rock, green hills, and dark lakes, with torrents pouring down the sides of mountains, whose summits were hidden in rain clouds. Sunshine appeared on some spots, whilst black clouds covered others; and, in the space of ten minutes, the spot on which I stood had been wet and dry.

"2. Amongst these mountains, I met with a singular race of beings, — the most gifted with vague curiosity of any men I have seen. They asked questions without considering whether they were civil or uncivil, and seemed little daunted by reproof.—*Q.* 'Where do you come from?' *A.* 'Ramelton.'—'Do you belong there?' 'No.'—'What place do you belong?' 'London.'—'Is it war or peace?' 'War.'—'Have the English lost any men?' 'There has been no battle lately.'—'When was the last?' 'Lord Nelson's; did you never hear of him?'—'No. What is your name?' 'It is a name you have never heard of, and never will hear of?'—The dialect and accent not similar to the Irish, but rather pure English, with many interlardings of unmeaning expressions, the most favourite of which was 'Teagues.' They all agreed that there were old men who knew the history of the Finns and Finn Macoul, in Gaelic; but no one could show me the abode of these sages.

"Four religions — a mountain religion (Covenanters), a Scotch kirk, a Romish church, and an English church. The kirk exceedingly troublesome,

and great enemies to Sabbath-breakers. A man hot with whiskey, and with the Presbyterian spirit, took away my rod on Sunday evening. The people of the town seemed to resent the injury, but rather too mildly. The people are in a state scarcely as yet prepared for improvement; the middling classes having rude hospitality, the lowest barbarous: gratitude, however, was striking. A boy applied to me for medicine; I prescribed for him, gave him physic, and, what was better, money: his gratitude was of the nobler kind. It is only in towns that the lower classes are depraved.

"Newtown Limavaddy, July 24.

"1. The road from Ramelton to Raphoe exceedingly hilly, cultivated; but bare stone walls, or mounds of earth, forming the enclosures.

"From Raphoe to Derry, for the first seven or eight miles, nothing worthy of observation. Great hills without rocks, enclosed, and gentle in their declivities. Within four miles of Derry, a view of the Foyle, a great river; here, indeed, an arm of the sea, affected by the tides: near Derry the banks wooded, and the whole landlocked; the hills of Donegal and the cliffs of Macgilligan in the back-ground. Derry a well-built and lively city; much business done, but I should conceive too remote from the main ocean to admit of a quick navigation to the ports of the north of England or Scotland, and not likely to rival Belfast.

"From Derry to Newtown Limavaddy, the first four miles through a flat cultivated country, backed by the hills of Donegal, bounding Loch Foyle; gradually scenes of beauty appear, fine woods on the banks of the sea; Scotch firs in abundance, birch,

oak, holly. The distances very grand. The blue face of Loch Foyle, bounded to the west by the grey misty land of Donegal, and to the east by the grand and elevated cliffs of Macgilligan, the bases of which smile with verdure and cultivation, and the summits of which abrupt crags frown barren, desolate, and exposed to all the storms of the north. Newtown Limavaddy beautifully situated on the banks of a little clear meandering river, and elevated upon a gentle hill: a plain beneath, with meads and light and beautiful woods; the near hills wooded, and mountains, with green sides and bare summits, in the eastern distance. The amphitheatre of mountains all of peculiar characters, and the character of the eastern chain marking a new country; a long line of ascent from the north, and a rapid declivity towards the south.

"2. The micaceous schist extends on the banks of the river of Newtown Limavaddy, having similar characters to those which it possesses in Donegal. Here, at Newton Limavaddy, rises the great basaltic cliff of Renavenac. No point of junction of this district with the schistose district appears. The summit of Renavenac is composed of a number of layers of basalt, rude in their forms, and grand in their outlines. Below the face of the cliff are irregular crags, containing an immense number of zeolites; zeolites, agate, and calcareous spars, are found in all the cavities of the basalt. The cliff can scarcely be less than 2000 feet above the level of the sea, and is exceedingly difficult of access. Small seams of coal are said to have been found at the base. A quarry of white limestone, with flints, has been broken in upon, and some scattered fragments of occur on both sides. The first

regular exposed superposition of basalt, with regard to chalk, is to be found at a cliff about three miles to the north. This chalk is of the same degree of consolidation as the lias limestone. Layers of single flints unaltered occur within six feet of it, and are seldom altered within two feet. These layers of flints are usually about two feet or twenty-eight inches asunder, and are usually about twice the size of the fist. The chalk stratum appears here at about thirty feet in height, and is topped by basalt, from three to four hundred feet probably. Immediately above the chalk is a great layer of flint, four feet in thickness, with a red intermediate substance. Here the flints are either reddened, white, or crumbly in some of their parts, and the basalt at the point of contact is very decomposable.

"The stratification of these cliffs is well marked. In one part these strata were distinct:—

"1. Irregular columnar basalt.

"2. Small tabular schistose decomposing basalt.

"3. Tabular basalt.

"4. An ochreous stratum of small thickness.

"5. Irregular tabular basalt, coming upon the flint in irregular outline.

"6. The flints generally red or white, and much fractured, with a soft ochreous substance between them.

"7. The chalk with its strata of flints declining towards the east, and lost about a mile off. The basalt likewise becomes lower towards the east, and the whole declination seems to be of this side."

His views relative to the political state of Ireland, founded on the observations which he made during

this excursion, are briefly and forcibly expressed in a letter to his friend, Mr. Poole, written after his return to London, in October, 1805 : —

"I long very much for the intercourse of a week with you : I have very much to say about Ireland. It is an island which might be made a new and a great country. It now boasts a fertile soil, an ingenious and robust peasantry, and a rich aristocracy; but the bane of the nation is the equality of poverty amongst the lower orders. All are slaves, without the probability of becoming free ; they are in the state of equality which the *sans culottes* wished for in France ; and, until emulation, and riches, and the love of clothes and neat houses are introduced amongst them, there will be no permanent improvement.

"Changes in political institutions can, at first, do little towards serving them : it must be by altering their habits, by diffusing manufactories, by destroying *middle men*, by dividing farms, and by promoting industry by making the pay proportional to the work : but I ought not to attempt to say any thing on the subject when my limits are so narrow ; I hope soon to converse with you about it."

Another letter to the same gentleman is deserving of a place, both in relation to his views on mining enterprises and the principles of government. It was written in the spring or summer of 1806 ; and, as appears from the concluding paragraph, when he considered himself on the eve of setting out on an excursion to the north of Europe ; but which circumstances, that I am not aware of, prevented his then acomplishing : —

"*To Thomas Poole, Esq.*

"My dear Poole,

"What you have written concerning the indifference of men with regard to the interest of the species in future ages, is perfectly just and philosophical; but the greatest misfortune is, that men do not attend even to their own interest, and to the interest of their own age, in public matters. They think in moments, instead of thinking, as they ought to do, in years; and they are guided by expediency rather than by reason. The true political maxim is, that the good of the whole community is the good of every individual; but how few statesmen have ever been guided by this principle! In almost all governments, the plan has been to sacrifice one part of the community to other parts; sometimes the people to the aristocracy; at other times, the aristocracy to the people; sometimes the colonies to the mother country, and at other times the mother country to the colonies. A generous enlightened policy has never existed in Europe since the days of Alfred; and what has been called 'the balance of power,' the support of civilisation, has been produced only by jealousy, envy, bitterness, contest, and eternal war, either carried on by pens or cannon, destroying men morally and physically! But if I proceed in vague political declamation, I shall have no room left for the main object of my letter—your mine. I wish it had been in my power to write decidedly on the subject; but your county is a peculiar one. Such indications would be highly favourable in Cornwall; but in a *shell limestone*, of late formation, there have as yet been no instances of great copper mines. I hope, however, that your mine will produce a rich store of *facts*.

"Miners from Alston Moor, or from Derbyshire, would understand your country better than Cornish miners; for the Cornish shifts are wholly different from yours. It would be well for you to have some workmen at least from the north, as they are well acquainted with *shell limestone*.

"The Ecton copper mine, in Staffordshire, is in this rock: it would be right for you to get a plan and history of that mine, which might possibly assist your views.

"Had I been rich, I would adventure; but I am just going to embark with all the little money I have been able to save for a scientific expedition to Norway, Lapland, and Sweden. In all climes,

"I shall be your warm and sincere friend,

"H. Davy."

At this time that my brother's attention was particularly given to geology, he formed the design of writing "Sketches of the Geology and Mineralogy of Cornwall;" and the following plan of them occurs in a note book, bearing the date of 1806:—

"1. Situation and general aspect of the country.

"2. Its soils and rocks considered in their physical arrangements.

"3. Granite.

"4. Micaceous schist.

"5. Serpentine.

"6. Porphyry.

"7. Limestone.

"8. Syenite.

"9. Of veins and dikes; their direction.

"10. Of the substances they contain.

"11. Of stream works.

"12. Of the mode of working veins.

"13. Of the mode of reducing the metals.

"14. Considerations on the productions of Cornwall.

"15. Economical considerations with regard to practical improvements, and a diffusion of theoretical knowledge."

The sketches thus comprehensively planned were begun, but not completed; the course of electro-chemical research and discovery, in which, about this time, or soon after, he was fully engaged, either drew off his attention from the subject, or did not allow him leisure to prosecute it. I shall insert the introduction, showing his manner of entering on the inquiry; and give two extracts, descriptive of the granite of the Land's End, and the serpentine of the Lizard.

"INTRODUCTION TO THE GEOLOGY OF CORNWALL.

"It is wholly impossible to give a complete and accurate geological and mineralogical history of any considerable district. Cornwall offers some objects which can, however, scarcely be attained elsewhere. Mines have been opened in it from the earliest times, and an immense number are still worked. The materials of the interior have been largely spread upon the surface, and not a few excavations are still open to the light of the day. Its hilly aspect likewise favours the researches of the geologist; for as nature has been unkind as to clothing the face of the country, the bare rocks, the bones, and, as it were, the sinews of the earth, are more perfectly disclosed. The sea likewise has intersected upon a great scale the strata of the country, and the Atlantic has displayed, in a series

of bold, majestic, and diversified cliffs, the general arrangements of the rocks of the district.

"Under such favourable circumstances, Cornwall presents a wonderful geological and mineral aspect; it is not like the cliffs of the south of England, composed of layers of limestone, sandstone, or chalk, or, like North Wales and the south of Ireland. It contains an immense variety of rocks, and its veins unfold the greater number of known mineral substances. At first view it would appear as the place in which fragments and ruins from the rest of the globe had been confusedly heaped together; but when it is correctly examined, its parts appear neither independent of arrangement, nor devoid of harmony and order.

"Though circumstances are very favourable for a mineralogical description of Cornwall, yet it is impossible, in the present state of our knowledge, to produce anything perfect on the subject. Though one of the most mineral districts in the world, yet still it is known only to a small depth in most places, and considerable portions of it, covered with soil, have never been examined by the borer; therefore a sketch only can be given, which, however, may be continually filled up in parts, and continually become more perfect and more useful. There is another apology for this publication. It may call the attention of good observers to the subject; it may supply analogies and ground for inquiries; and, in the particular case, may be what the able agenda of De Saussure are to the general science."

"In the great arrangements of the masses of granite of Cornwall, the rock appears composed of

an immense number of blocks of different sizes. This structure is no where more perfectly exhibited than in the western cliffs. The incessant agency of the Atlantic, its storms and its waves, have washed away or destroyed all the loose materials of the shore, and left abrupt eminences of rock, from 50 to 360 feet in height. At Castle Treene, three groups of granite occur; the highest 360 feet in height, the lowest not less than 200 feet. The arrangement is in masses, which approach to the cubical form, having, however, rounded edges, heaped upon each other, and in some of their parts covered with lichen and a thick moss. On the middle group stands a granite block of about forty feet in girth, poised upon the rock beneath, so that a small force is sufficient to move it. Between the blocks there is evidently no junction, as happens in the rocks of the basaltic family.

"The masses are grand, their colours uniform, and their uniformity increases the effect upon the eye; and the arrangements of this kind have a peculiar wildness and sublimity. No where is it seen upon a greater scale, or in a more magnificent assemblage of forms, than from a point between the Land's End and Castle Treene. Both these grand promontories appear extending into the Atlantic; the cliffs between them are abrupt and lofty; the waves are broken by a number of small island rocks which are scattered along the shore. The few portions of soil that appear above the cliff are covered with short green grass, tufted with heath and furze, which, in the autumn, present mixed hues of purple and gold. The rock throughout is of a uniform yellowish red, the tint perfectly contrasted to the blue-greens of the sea."

"The serpentine of Cornwall occurs only in one district, the Lizard; but it is a rock of considerable extent, and very diversified in its appearance. Its colours are various; green, red, grey, black, and olive, are the common; and where it is in a state of decomposition it is brown: it assumes no regular stratification, but appears in small irregular blocks, which are joined to each other; and its usual form is that of a shining smooth surface, intersected by a number of lines and chasms of different sizes. The Lizard district is a low uniform land, covered, where there are no cliffs, with green grass, and particular varieties of the heath erica vagans: its greatest elevation is not more than 400 feet.

"The serpentine of Cornwall is far from being a simple rock, or one uniform in its texture; when minutely examined, even in the most compact specimens, it appears constituted by many parts: resplendent hornblende, mica, talc, and felspar, are its principal constituents; occasionally with quartzose veins, and very often veins of asbestos, steatites, and calcareous spar: the green colour is generally caused by the steatites, the red by the red resplendent hornblende, and the brilliant specks are the talc and mica. In some rocks the separate crystals are upon a great scale, and the composition of the substance obvious, even to common observation. At Coverac, the resplendent hornblende and felspar occur as separate elements, of from one half to two, three, and four square inches in surface, and nothing can exceed the beauty of the combination. The felspar is of a bright white, or pale pink colour, the diallage of a deep red or green, and the talc a light fawn colour. The rock is spotted in the most beau-

tiful manner, and its arrangements elegant and fantastic, and contrasted with the columnar arrangement, as its tints are with the uniform tints of the syenite below. From these large crystals there is a gradation to the smallest, till the rock becomes in appearance compact and uniform. The cliffs at Kinnance exhibit all the varieties of serpentine, and all its most beautiful colours and combinations, both in a minute and on a grand scale. Rocks of from 200 to 300 feet in height form its boundaries; numerous islands are interspersed in the bosom of the bay; caverns of the most beautiful kind occur, having a floor of the purest and most sparkling white sand; the lustre of the rock, polished by the sea, approaches to that of the metals, and the scene has in it the character of something above nature, and connected with supernatural agency and beings."

These two rocks, the granite and serpentine of his native county, were, I believe, the first he studied when he commenced the pursuit of geology, and both of them were to him particularly attractive; the granite in its grand forms, and the serpentine in its forms of beauty. The finest examples of these rocks were within a day's ride of Penzance; and when he visited home, a young man, he never failed paying the Lizard and the Land's End a visit, and generally in company with some of his old schoolfellows. I remember, when a boy, being allowed to join one of these parties to the Land's End, and it was a merry one, as youthful parties commonly are. After exploring the cliff scenery, we dined at a tavern at St. Just, and I well recollect the boisterous mirth indulged in after the repast was concluded, and the

wine had circulated; the gymnastic feats attempted; the shouts of applause, the unconstrained laughter, and all that abandonment of spirit to mirth so common in young persons under excitement, and which, excepting in youth, can scarcely be felt or enjoyed.

Fond of his native county, he took a lively interest in every thing that regarded its welfare, and was very desirous of seeing improvements introduced into it. The 15th section in the scheme of the "Sketches of Cornwall" indicates this. He was desirous that a school of mines should be established there, similar to those which have been long founded in Germany, and are there so useful in forming enlightened miners, by the aid of a happy union of theoretical and practical knowledge. He witnessed with pleasure the institution of a geological society in Cornwall, and he most willingly afforded it his aid, both by a donation of money, and a present of a collection of some value of specimens of the products of Vesuvius, and by a contribution to its Transactions.* This paper was entitled "Hints on the Geology of Cornwall." It is the only paper he ever wrote for publication on a geological subject, and it contains some valuable theoretical views.

During his summer and autumn excursions, occasions often occurred to excite into activity his poetical temperament and powers, as is shown by the verses which remain, written at the moment, embodying the sentiments called up by the scene or event. Two specimens of these verses have been already given, and I shall give some others expressive of his manner of viewing nature, his love of home, and the kindly and lofty tone of his mind.

* Vol. i. p. 38. *et seq.*

The following lines, I believe, were written on his first visit to the Western Islands; they may give pleasure to the individuals whose kindness and virtues he commemorates, or their descendants: —

"Whoever, glowing with the holy love
Of wild magnificence of ample form,
Has visited these islands, where, upraised
Above the vast Atlantic, boldly stand
The giant monuments of elder time,
The pillar'd caves of Staffa, and the rocks
Of fair Iona, let him kindly bless
That peaceful and that hospitable shore,
Where stands the House of Ulva; for its halls
Are graced by virtue, elegance, and taste,
By social joy and welcome from the heart.
In them the weary traveller finds repose,
And quits them with regret and gratitude."

The next lines, relative to his birthplace, occur detached, and are a mere fragment: —

"There did I first rejoice that I was born
Amidst the majesty of azure seas,
Surrounded by the everlasting form
Of mighty rocks, on which alike the waves
And the harsh fury of the storms of heaven
Beat innocent. Eternally allied
Pleasure and hope connected with the scene
Infix'd its features deeply; and my mind,
Growing in strength, with livelier zeal
Still looked on Nature."

The following little poem, as stated in the heading to it, was "written in the coach, December 25. 1803, passing from Bath to Clifton": —

"When in life's first golden morn,
I left my stormy native shore,
My pathway was without a thorn,
With roses it seem'd covered o'er.

"Ambition thrill'd within my breast,
My heart with feverish hope beat high;
Hope alone disturb'd my rest,
Hope only bade me heave a sigh.

"In pride of untried power my mind
  A visionary empire saw,—
A world, in which it hoped to find
  Its own high strength a master law.

"Its love was wild, its friendship free,
  Its passions changeful as the light
That on an April day we see,—
  Changeful, and yet ever bright.

"Years of pain have pass'd away,
  Its former lineaments are gone;
Hope gives it now a gentler ray,
  Ambition rules it not alone.

"The forms of holy truth severe
  Are the fair thoughts with which it glows;
And if it ever feels a tear,
  That tear in purest passion flows.

"Fled is its anguish, and its joys
  Are such as reason may approve;
No storms its quietness destroys,
  Yet is it ever warm with love.

"Its pleasures Fate and Nature give,
  And Fate and Nature will not fly;
It hopes in usefulness to live,
  In dreams of endless bliss to die."

The next stanzas were written in 1806, on two mountains mentioned more than once in the journal of his Irish tour, as forming grand and peculiar features in the scenery:—

"Mucrish and Arokil, ye pair
Of mighty brethren, rising fair
  Amidst the summer evening's western light;
Clouds might ye be, so bright your hue,
So dense your purple in the blue
  That ushers in the night,

"Were ye not motionless; your forms
Unchanged by breezes or by storms,
  The same from day to day, from age to age,
Unalter'd midst the wrecks of time,
Scorning in giant strength sublime
  The whirlwind's and the lightning's rage.

"Summer's wild heathblasts, winter's snows,
Disturb not your supreme repose:
Not the mild influence of spring,
Clothing the lowlands all in green,
Creating round a joyful scene
Of change to you can bring.

"Not e'en the purple heath expands
Its foliage o'er your blanched sands;
Your rocks alone the yellow lichen covers,
In palest tints, and o'er the space ye own,
No shapes of life are known,
Save where the eagle hovers.

"His screams, the mountain torrents' sound,
The mountain breezes whistling round,
The distant murmurs of the western wave,
Compose the music wild and rude
Of your unhaunted solitude,
Else silent as the grave.

"The glens that ranged around your feet
In grand confusion seem to meet,
As with your parts to harmonise,
While they your fountains drink,
In kindred wildness sink
As ye in wildness rise."

I shall give one more little poem (it is a fragment) connected with his Irish tour, written on Fair Head, displaying his habitual feeling and admiration of nature, and philosophic mode of blending perception and reflection. It is taken from Dr. Paris's work, to which it was contributed by Mr. Greenough, who was his companion in these travels.

"But, chiefly thee, Fair Head!
Unrivall'd in thy form and majesty!
Far on thy loftiest summit I have walked
In the bright sunshine, while beneath thee roll'd
The clouds in purest splendour, hiding now
The ocean and his islands, parting now
As if reluctantly; whilst full in view
The blue tide wildly roll'd, skirted with foam,
And bounded by the green and smiling land,
The dim pale mountains and the purple sky.

Majestic cliff! thou birth of unknown time,
Long had the billows beat thee, long the waves
Rush'd o'er thy hollow'd rocks, ere life adorn'd
Thy broken surface, ere the yellow moss
Had tinted thee, or the wild dews of heaven
Clothed thee with verdure, or the eagles made
Thy caves their aëry. So in after time
Long shalt thou rest unalter'd mid the wreck
Of all the mightiness of human works;
For not the lightning, nor the whirlwind's force,
Nor all the waves of ocean, shall prevail
Against thy giant strength, and thou shalt stand
Till the Almighty voice which bade thee rise
Shall bid thee fall."

After the relaxation of the country, he always returned to London, in improved health and vigour, and with renovated zeal in the cause of science. His mixed feelings, on these occasions, are vividly described by himself in his last work.

"In my youth and pride of manhood (he says), I never entered London, without feelings of pleasure and hope. It was to me as the grand theatre of intellectual activity; the field of every species of enterprise and exertion; the metropolis of the world of business, thought, and action. There I was sure to find the friends and companions of my youth, to hear the voice of encouragement and praise. There society of the most refined kind offered daily its banquets to the mind, with such variety, that satiety had no place in them; and new objects of interest and ambition were constantly exciting attention either in politics, literature, or science."

It was then, in the latter end of autumn, and the beginning of winter, before the opening of the Institution, that he generally applied himself with the greatest assiduity to his favourite pursuit of experimenting, and this was the period of some of his

most successful labours, which have been recorded in the Bakerian Lectures, that for five years successively he delivered to the Royal Society, viz. from 1806 to 1810. The results of these and his other investigations, from the time that he published his "Researches," in 1800, require particular consideration.

CHAPTER V.

SKETCH OF HIS SCIENTIFIC PURSUITS BETWEEN 1800 AND 1807.—PART OF A LECTURE OF HIS SHOWING THE PROGRESS OF ELECTRICAL DISCOVERY.—EXTRACT FROM HIS LAST BAKERIAN LECTURE ON THE SAME SUBJECT, IN VINDICATION OF HIS RIGHTS.—NOTICE OF HIS FIRST BAKERIAN LECTURE.

In noticing my brother's scientific labours, I shall avoid minute details; I shall endeavour, in as brief a manner as possible, to point out the most remarkable parts of them, those most interesting in relation to the progress of discovery, and most characteristic of the powers of his mind. Whenever an opportunity offers, I shall have recourse to his lectures, and give his own narrative of events. The scientific reader who wishes for full information, and to follow him step by step in his researches, I must refer to the Philosophical Transactions, and to his published works.

During the period we are now considering, namely, from 1800 to 1807, his attention was directed to a great variety of objects of inquiry, but more particularly to the following:—1st, Galvanism, and electro-chemical science, which, chiefly under his cultivation, sprang from galvanism. 2d, The investigation of astringent vegetables in connection with the art of tanning. 3dly, The analysis of rocks and minerals, in connection with geology. And, 4thly, the comprehensive subject of agricultural chemistry.

We have seen that he commenced the study of

chemistry in the latter end of 1797; and it appears that about the same time, or very soon after, he applied himself to electricity; for in a paper, published in Nicholson's Journal for 1805, containing "Notices concerning some Philosophical Apparatus*," he alludes to electrical researches, in which he was engaged in 1798; and it is worthy of remark, that even then, when he must have been a novice in the science, not satisfied with merely learning what was known, he immediately applied himself to original inquiry, and invented an electrical battery, in which talc was substituted for glass, on the principle established by Mr. Cavendish, that the capacity of a substance for an electrical charge is *cæteris paribus* inversely as its thickness.

The same bias towards original research even more strongly showed itself on his resuming his electrical inquiries in 1800. That year is remarkable for the great invention which bears the name of its author — the Voltaic pile or battery — and for the accidental observation of the decomposition of water by means of it; or, to express the fact simply, the separation of water under its agency into oxygen and hydrogen. This very remarkable effect of the pile of Volta, which Messrs. Nicholson and Carlisle had the merit of first noticing, immediately impressed powerfully the mind of my brother. He saw in it the connection between galvanism and chemistry; he expected that it might prove a link between the ponderable and imponderable substances; and he had prophetic warnings that it was a passage to a new world of discovery. He was at that moment in-

* Nicholson's Journal, vol. v. p. 210.

tensely occupied in completing and preparing for publication his researches on nitrous oxide. As soon as he was free from this labour, he entered on the new inquiry, and prosecuted it with an ardent zeal, of which the papers he published on the subject are a proof; though less forcible than his note books, in which a vast number of experiments are recorded, either as *agenda* or *acta*, in rapid succession.

That the reader may have before him a connected view of the progress of electrical discovery, I shall insert from a lecture in MS. (part of a course for 1810, on electrical science) a sketch of its history, with some additional details of the same kind from his Bakerian Lecture for 1826. A great part of the first mentioned is a popular view, and may interest the general reader; and I offer it as another specimen of his manner of lecturing to a mixed audience.

He commences with observing, "That an historical view may be useful, as offering a kind of map of the science, and of the roads by which it has been explored."

"In a sketch of this kind," he continues, "and in the time allotted for it, I shall not be expected to produce a minute history of all the various insulated experiments that have been made. My endeavour will be rather to fix your attention upon the leading and grand discoveries, which form the epochs of the science. The brilliancy of electrical phenomena, and the facility of producing them, led an immense number of inquirers into this field of research. Many have developed new objects in it, but a very few only have ascertained principles; and in philosophical annals the fame of subordinate improvers is necessarily absorbed in that of the noble inventors,

as in military details the worth of the common soldier and of the subaltern is, as it were, swallowed up in the glory of the general."

The first epoch of electrical science must be referred to the time of Gilbert, and his views are developed in the "Treatise de Magnete," published in 1600. The ancients were acquainted with two electrical bodies only — amber, ελεκτρον, which has given the denomination of the science; and lyncurium, which is either the topaz or tourmaline. Gilbert ascertained that a great variety of substances are capable of being excited,—as glass, sealing wax, resins, gums, and most of the earthy and stony bodies; and that their electricity was impaired by moist air and aqueous fluids, but not by oily and resinous substances; and he supposed electrical attraction to be a general property of matter, and thus contrasted with magnetic attraction, which was peculiar to bodies containing iron.

"His work is worthy of being studied, and I am surprised that an English edition of it has never been published. Gilbert was a man above his age; in his own times, his philosophy was little attended to, and one reason why it was neglected in later periods is the singular reproach thrown upon it by the great father of modern experimental philosophy. 'Men,' (says he, in his book 'De Augmentis Scientiarum,') are continually carrying too far their own favourite theories, and endeavouring to accomplish every thing by their own peculiar arts. Thus, Plato has made all philosophy, theology; Aristotle, logic; and Proclus, mathematics; following these sciences as their first-born children, and making them their heirs to the exclusion of all others. So

the chemists explain all things by the processes of the fireplace and the furnace; and our countryman, Gilbert, has attempted to raise a general system upon the magnet, endeavouring to build a ship out of materials not sufficient to make the rowing pins of a boat.' In another place he treats the important electrical facts which Gilbert had discovered as fables. The illustrious critic of the sciences was occasionally misled by his zeal for the destruction of prejudices and false opinions, and by his contempt for the absurdities of the ancient schools. Anxious to build up his own great edifice with his own materials and by his own strength, he refused all assistance; and, the founder of a new and grand philosophy, he scorned to blend either the facts or the opinions of others with what he conceived to be peculiarly his own work. Confident of greatness, and looking with a steadfast eye towards the creations of his own noble genius, he did not fully see the merit of others; as in the meridian light of our own sun we cannot perceive the stars, which are, nevertheless, the suns of other systems. No one can exceed me in admiration of this great man; and it is with a feeling of humility that I venture to say, that his reproach of Gilbert is unjust. Gilbert undoubtedly considered the earth as endowed with magnetic poles, and this is now acknowledged as a truth. He perfectly and most accurately distinguished between magnetic and electrical attraction; and he supposed by a singular felicity of induction, and with a kind of prophetic sagacity, that the motions of the heavenly bodies might depend upon a peculiar gravitation or attractive power. He was far from possessing an unwarrantable spirit of generalisation. In his Latin preface, he says, in words which may be

thus translated, ‘My object is to arrange facts, founded on trials of the properties of natural things, and to give to my subject demonstrations similar to those adopted in geometry, which, on the most simple foundation, raises the most magnificent works; which, by a few propositions, founded on the properties of things belonging to the earth, enables the mind to comprehend the structure of the heavens. I renounce all subtleties connected with letters. I depend upon things which may be made evident to the senses, things which may be easily tried: and nothing in this treatise has been done in haste; every experiment has been carefully repeated.’ *

* Gilbert not unfrequently breaks out in reprobating the scholastic manner of philosophising in terms even more severe than Bacon was in the habit of using. Thus he begins his tenth chapter, “Deploranda est humana in rebus naturalibus inscitia, et tamquam in tenebris somniantes excitandi sunt moderni Philosophi, et ad verum usum et tractationem educendi, ab otiosa ex libris quæsita doctrina probabilium rationum nugamentis et conjecturis tantum suffulta.” And, with the same feeling in another place, he justly remarks, “Facile est hominibus ingenio acutis, absque experimentis et usu rerum labi et errari.” P. 52. Tractatus, sive Physiologia Nova de Magnete. Sedini, 4to. 1633. And, in a posthumous work, “De Mundo nostro sublunari Philosophia Nova,” in several places he expresses himself no less strongly to the same effect. Thus, at p. 5., speaking of the influence of Aristotle and Galen on the schools, he says, “Tunc omnes in hæc verba jurare oportuit, tunc ad religionis normam docendi et disserendi forma redacta est, et mandatum has etiam juventuti nugas offerre, singulasque bonarum literarum scholas decretum intravit, *ipse dixit, Aristoteles dixit, Galenus dicit,* exivit discipulus quid diceret instructus; quid fecerit ignorans plane et inscius.” And, again, at p. 74., after noticing some of the different definitions and accounts of the elements by the ancient philosophers, he remarks, “Ita varie etiam actum de definitione elementi, non minore contentione quam de elementis ipsis et numero ipsorum; falsæ enim suppositiones infinitas gignunt garrulitates.” This work of Gilbert’s, which is so little known, is a very remarkable one, both in style and matter; and there is a vigour and energy of expression belonging to it very suitable to its originality. Possessed of a more minute and practical knowledge of natural philosophy than Bacon, his opposition to the philosophy of the schools was more searching and particular, and at the time probably little less efficient.

"About fifty years after Gilbert, Boyle, and Hooke, and Otto de Guerike, pursued the subject of electricity; and Otto de Guerike erected the first electrical machine, which was a globe of sulphur whirled upon an axis, and rubbed against the hand. Hawksbee, in 1709, substituted globes and cylinders of glass for the globe of sulphur; and has described in the Philosophical Transactions, and in his physico-mechanical experiments, a great number of the luminous phenomena of electricity.

"The electrical effects at this time were, however, referred to no general principle, and they were explained by different inquirers in very different manners, and attributed either to rude mechanical causes, or to some occult specific qualities of the different bodies exhibiting them. This, at first view, appears wonderful; for in the beginning of the eighteenth century the methods of philosophical research attained their highest degree of perfection, and the public mind, generally speaking, seems to have been in that happy state in which the imagination and activity of youth are, as it were, chastened by the correctness and sagacity of manhood. But the reason seemed to be, that the objects of the philosophy of the Newtonian school absorbed for at least half a century all the attention of scientific men. The grand laws of the system of the universe came upon the understanding with that kind of effect which the new sensations of vision produce on the blind receiving sight. The mathematical theory of philosophy and astronomy, the laws of light, and the motions of the heavenly bodies, were the universal topics of discussion and admiration.

"It is not a little remarkable that the first fact communicated by Newton to the Royal Society was an

electrical experiment, and that the truth of his statement was doubted by some of the members of that illustrious body. The secretary was ordered to write to him to relate its failure. They were satisfied by the answer, which, however, proved that the young philosopher was offended by their doubts of his accuracy. If they had persisted in a mistake, it is not impossible that a disgust might have been produced fatal to the cause of science, for it was the connection of Newton with the Royal Society which induced him to bring forward and publish his works. Equally distinguished by modesty as by exalted genius, he pursued science, because his spirit was imbued with an ardent love of truth and an insatiable desire of knowledge. His ardour could not have been damped by opposition; but his love of quiet might have led him to avoid controversy. But it is in vain to speculate upon what might have taken place. He was surely destined for the great purpose which he accomplished, — to exhibit the dignity of the human mind; its wonderful resources; and to show the magnificence and simplicity of nature.

"The second epoch of electrical science cannot fairly be placed further back than 1730, the time in which Stephen Grey and Du Fay commenced their labours. Mr. Grey's papers may be found in the Philosophical Transactions from 1730 to 1740. Grey gave up his whole mind to the inquiry, and pursued it with his whole heart. He multiplied his experiments with indefatigable industry, and, through a period of nine years, his papers occupy a considerable place in the Philosophical Transactions of the Royal Society.

"Amidst a great number of unconnected facts and observations, two discoveries of prime importance occur, — the power of electrified bodies to communicate their influence to other bodies, and the distinction between conductors and non-conductors. Mr. Grey discovered the insulating apparatus, and was the first person who rendered metals, water, and the human body electrical by communication with excited instruments. Grey was a great benefactor to the science; but he was more distinguished for liveliness and perseverance of research than for accuracy and strength of thought. His facts are infinitely more valuable than his theories. Having little general knowledge of science, he erred in what may be called the critical philosophy of his subject; and attempted to explain gravitation, and other recondite powers of matter, by delusive electrical experiments. Thus affording an instance of the truth of that capital dogma of Aristotle, that "those who know only one thing find it easy to account for every thing."

"Stimulated by the first discoveries of Mr. Grey, Monsieur Du Fay, intendant of the French king's gardens at Paris, entered upon the same plan of investigation, repeated the different experiments made in England, and added to them various new ones connected with brilliant and important results.

"M. Du Fay was the first person who distinguished the two electricities under the names of *resinous* and *vitreous,* and he ascertained the very considerable principle that 'bodies similarly electrified repel each other; but that bodies dissimilarly electrified attract each other.' His discoveries are published in eight memoirs, delivered to the Academy of

Sciences, and inserted in their History for 1733, 1734, — 1737. His writings display a truly philosophical spirit. He has attempted, in all cases, to generalize on the phenomena, and patience and accuracy seem to have equally regulated his practical researches and his speculative views. He refers to the known facts, to a few propositions; and the germ of a good elementary treatise may be found in his papers. He was an acute and sagacious observer, warped by few prejudices, led away by no fancies.

"After the researches of Grey and Du Fay, nothing that materially affected the progress of the investigation was ascertained till 1745, the year of the discovery of the Leyden phial, which may be regarded as constituting the third epoch in the science. This extraordinary apparatus was first employed by the Canon Von Kleist, of Kamin; but a similar combination was soon after invented by Cunæus and Muschenbroeck, of Leyden. Kleist's form of the experiment was a phial held in the hand, having a nail in it; Muschenbroeck's form was a phial half filled with water. Nothing in the history of electricity is more singular than the first accounts of the electrical shock, as given by these very feeble and imperfect instruments, and the astonishment of the discoverers seems almost to have deprived them of their reason. Muschenbroeck, in his account of the experiment, written to Reamur, states, that 'the effect from a small glass bowl was so violent, that he lost his breath and his sensation, and was two days before he recovered from the effects of the blow and the terror; and that he would not take a second shock for the whole kingdom of France.' It does not require another example to demonstrate how much the

imagination and the senses influence each other. Other philosophers, with a much more perfect and more powerful apparatus, repeated the experiment without any such terrible effects, and referred to the cowardice of the professor what was only the effect of his surprise.

"No single philosophical discovery ever excited so much popular and scientific attention as this of the Leyden phial. The apparatus soon became an object of public exhibition; and in the same year in which it was discovered, a number of itinerant experimenters procured a livelihood in different parts of Europe by travelling from place to place, and showing the experiment. About the middle of the last century, an immense number of facts had been ascertained, and they were constantly accumulating, and some principles had been developed; but a general theory for connecting the insulated observations, and giving them the form of a body of science, was still wanting. The foundations for this theory were laid by the ingenuity and industry of our countryman, Dr. Watson; the construction of it is owing to the sagacity of Dr. Franklin. Dr. Watson ascertained that a communication with the ground is necessary for the production of a continued stream of electricity by the machine; and hence he concluded that there is an afflux of electricity from the conducting bodies to the glass, and from the glass to the prime conductor. This idea was made known early in 1747, and towards the middle of the same year Dr. Franklin transmitted his first letter on the subject to Mr. Collinson, containing an account of experiments and observations on electricity made at Philadelphia. In this letter, and in several subsequent letters, in a correspondence

that continued till 1774, he brought forward those enlightened ideas of the subject which have been so generally admired, under the name of the Franklinian Theory. Dr. Franklin proved that the conductor in contact with the rubber of the electrical machine had an opposite electricity from that of the great conductor; that the outside and the inside of the Leyden phial were likewise in opposite states, and that an equilibrium was made by their mutual agency: and he referred all the phenomena to the redundancy or deficiency of a single fluid. The experiments adduced by Dr. Franklin in support of his hypothesis were most ingeniously contrived and happily executed. A singular felicity of induction guided all his researches, and by very small means he established very grand truths. The style and manner of his publication are almost as worthy of admiration as the doctrines it contains. He has endeavoured to remove all mystery and obscurity from the subject; he has written equally for the uninitiated and for the philosopher; and he has rendered his details amusing as well as perspicuous — elegant as well as simple. Science appears in his language in a dress wonderfully decorous, the best adapted to display her native loveliness. He has in no case exhibited that false dignity by which philosophy is kept aloof from common applications, and he has sought rather to make her a useful inmate and servant in the common habitations of man, than to preserve her merely as an object of admiration in temples and palaces. The theory of negative and positive electricity was soon made by M. Æpinus, of the Academy of Petersburgh, the subject of mathematical illustration; and this pro-

found algebraist has submitted a great variety of the conditions of electrical action to calculation, assuming as his data an attraction between the electrical fluid and common bodies, and an excess or deficiency of the fluid, or of the matter over which it is diffused.

"A more popular, and not less refined, view of the same doctrine was soon after furnished by Mr. Cavendish, who has combined delicacy of physical experiment with elucidations derived from the higher branches of mathematical science, and whose researches in electricity have the same exalted character as those in the other departments of natural philosophy.

"The magnificent effects produced by the accumulation of electricity by large machines and jars soon led philosophers to reason from artificial concerning natural processes. Such an influence it was impossible to conceive passive in the external world, and the most striking analogies soon led to the discovery of its most obvious operations. Dr. Stukely and the Abbé Nollet had observed the similarity between the electrical spark and lightning and the report of thunder; but Dr. Franklin was the first philosopher who conceived the bold idea of bringing lightning from the clouds,—who first imagined that by pointed conductors, charged electrical clouds might be made harmless, and the matter of the thunderbolt quietly conveyed from the atmosphere to the earth. The simple apparatus of a school-boy's kite, held by means of a silk handherchief attached to a hempen string, with a key for a conductor, enabled him, in June, 1752, to verify the grand idea. The practical application soon followed, and, what rarely happens, the

same philosopher had the glory of discovering a noble principle in nature, and of making it of public utility.*

"The simple path once opened, a great number of philosophers immediately engaged in the inquiry concerning atmospherical electricity, and a general and copious account of their researches may be found in Priestley's history.

"Beccaria and Canton determined the influence of charged strata of air in the phenomena of lightning; and the Italian philosopher made a number of applications of theory to the nature of clouds, the affections of the winds, the aurora borealis, and other appearances. Experiments on thunder storms were pursued by a variety of persons with great zeal, and sometimes with too little caution, when it is considered what an intractable and powerful agent was concerned in the operations. Amidst such a variety of trials in different parts of Europe, only one serious accident happened, and but one victim fell in the dangerous field of research. Professor Rickman, of Petersburgh, was examining the electricity of a thunder cloud by means of a new instrument, which he called an electrical gnomon; the experiment was fatal: a discharge took place with a loud explosion, and the philosopher

* M. Arago, in his Eloge Historique of Volta, published in the 54th volume of Annales de Chimie and de Physique, gives credit to Dr. Wall in 1708, and to Stephen Grey in 1735, for the earliest conjectures respecting the electrical nature of the phenomena of the thunder storm; but the analogy which these ingenious inquirers hinted at was so vague, that it might almost be considered poetical: the authors themselves attached no importance to it, nor appear to have given it a second thought, and which certainly had been passed over by posterity as trifling had not a kind of importance more than due been given to their expressions by the great discovery of Franklin.

fell instantly dead, immortalised as the first and the only martyr to the science.

"In 1774 a new electrical inquiry was brought forward by Mr. Walsh. The powers of the torpedo and gymnotus to give shocks had been long known. This gentleman proved, by the most satisfactory experiments, that the effect was electrical. And Mr. Cavendish contrived to imitate the electricity of these fishes, by a number of Leyden jars, weakly charged. The electrical organs, dissected by the celebrated John Hunter, were found to be composed of columns of muscular and membranous substances furnished with large nerves; and it seems exceedingly probable that the electricity is excited, as in other cases, by contact, and accumulated by induction.* In presenting the Copley medal to Mr. Walsh, as a testimony of the approbation of the Royal Society of these his discoveries, Sir John Pringle, then president, in the speech made on the occasion, entered into some noble views, in which there are striking hints of later discoveries; and after stating that there may be still found out new and more powerful modes of exciting electricity, and of submitting bodies to its operation, he concludes in his usual animated manner: 'But whether this will be the individual effect or not, philosophy, by these curious and successful researches, has made a valuable acquisition, since we may be assured that whatever tends to disclose the *causæ rerum*, the secret laws of nature, cannot ultimately fail of subjecting her, more or less, to the uses of

* The existence of muscular substance in the electrical organs of the torpedo is more than doubtful. Vide my paper on the subject in the Phil. Trans. for 1832, where the question is discussed.

life, and of manifesting, more and more, the wisdom and power of the Creator in all his works. This animal served them (meaning the ancients) for an emblem or hieroglyphic, for a figure of speech, or an allusion of pleasantry, — at best, as a theme for a copy of verses. But the world, rising in years and in wisdom, rejects such trifles. The interpreters of nature, in the adult state of time, make experiments and inductions, distrust their intellects, confide in facts and in their senses; and by these arts drawing aside the veil of nature, find a mean and grovelling animal armed with lightning — that awful and celestial fire revered by the ancients as the peculiar attribute of the father of their gods?'

"After this period, which may be considered as the fourth epoch of the science, for several years electrical science may be said to have slept, or, at least, not to have been distinguished by any grand advances. This was the great era of chemical discovery, and philosophical minds were fully busied with other important investigations. Electricity seemed as if nearly exhausted as to all sources of grand discovery; and the love of glory, as well as love of novelty, led ardent inquirers into the extensive and uncultivated field of pneumatic research.

"Whilst the discoveries concerning the gases were pursued, no other improvements were made in electricity than a few connected with the construction of instruments; and a mere accidental circumstance led to the pursuit of that novel branch of the inquiry which, for the last eighteen years, has been so wonderfully extended, and elucidated under the name of galvanism. It had long been known, and the then recent discoveries made by Vassali had shown, that

common electricity produced contractions in the limbs of animals just deprived of life. Galvani, professor of natural philosophy at Bologna, in 1789, happened, in some physiological experiments, to touch the crural nerve of a dead frog with a knife; violent contractions were produced in the leg: he tried other metals with similar effects, and he found combinations of metals much more efficacious than simple metals.

"The true discovery of Galvani was that of a delicate animal electrometer. The conclusion ought to have been, that combinations of the metals were rendered electrical by contact. But ideas very remote from this were formed by Galvani and his followers. They conceived that the metals were merely conductors of an etherial fluid existing in the animal organs, and that this fluid was the cause of irritable action. Innumerable experiments were made by Humboldt, by Aldini, by Valli, to determine the laws by which it was governed. The highest physiological discoveries were anticipated; the functions of vitality were supposed to be capable of analysis; and a spirit of generalisation was indulged in, romantic, and far removed from that of sound reason and unprejudiced investigation.

"The same year that Galvani made his observations, Mr. Bennet showed that the metals gained electrical powers by contact or friction; and he was enabled to determine this by means of an extremely delicate instrument of his own invention, in which gold leaf is exposed to the body examined, and in which, by particular artifices, the electricity is increased.

"One of his simplest experiments was to touch a

plate of copper with the blade of a knife, — an effect is found to be produced, in a slighter degree, similar to that produced by the friction of sealing-wax. This discovery, which contained the solution of the experiment of Galvani, was published in a distinct treatise, containing many curious electrical experiments in 1789; but it was neglected for ten years, till the singular phenomena comprehended under the name of galvanism began to occupy the public attention.

"Volta, in opposition to Galvani, and the advocates of the physiological hypothesis, always asserted that these phenomena were merely owing to the electricity of the metals, and made still more decisive experiments than those of Mr. Bennet on the subject; and this illustrious philosopher put the question beyond doubt by the grand invention of the new electrical battery.

"This noble invention, in which the powers of the electrical machine, the Leyden phial, and the organ of the gymnotus, are, as it were, combined and concentrated, brought forward in the first year of a new century, forms the fifth, and not the least important, epoch in electrical discovery; and it has the greater merit, as being the result of thought, and not of accident, — as being at once a demonstration of the principle of the author, and a novel and astonishing combination.

"As it is to Volta that we owe the great progression in the science, it is wholly inconsistent with the feeling of justice that the name of Galvani should be associated with his discoveries. Galvanism and galvanic batteries will, I trust, soon become obsolete terms; and voltaic electricity and voltaic batteries

take their place. Let honour be given where honour is due, but let not the new and magnificent facts belonging to the novel discoveries be associated with a name to which they bear no relation. Let not the accidental discoverer of an insulated phenomenon, which he was unable to explain, be placed before a *philosopher*, whose inventions were the result of combination, and whose views have uniformly been as sagacious as his experiments are accurate.

"Solids were, till the time of Volta, supposed to be the only substances which could be made electrical, or, as it was usually called, excited; but Volta showed that fluids are possessed of this property. One of his experiments was to fill a cup of silver with a solution of liver of sulphur; a leg of a frog made to touch both the silver and the solution undergoes violent contraction.

"Even elastic fluids, — air, and probably all the different gases, — are capable of exhibiting electrical effects. Thus, a strong stream of air forced against brass, connected with gold leaf, very sensibly affects it; and, as far as we are able to judge, from the great collection of facts, all the substances in nature are capable of exhibiting the power. Its effects are, probably, as comprehensive as those of gravitation; and when they are thoroughly understood, they will probably be found not less important.

"The voltaic battery was as an alarm-bell to experimenters in every part of Europe; and it served no less for demonstrating new properties in electricity, and for establishing the laws of this science, than as an instrument of discovery in other branches of knowledge; exhibiting relations between subjects

before apparently without connection, and serving as a bond of unity between chemical and physical philosophy.

"In so rich a harvest of discovery many were anxious to be partakers; and perhaps no equal period of philosophical history exhibits a more brilliant picture of the activity and power of the human mind, seeking for a new empire over the natural powers of things, than may be contemplated in the annals of the last eight years."

Let us now turn to the historical details which he has given in his Bakerian Lecture for 1826 of this most interesting period; details in which, whilst he vindicates his own invaded rights as a discoverer, he does ample justice to the rights of others:—

"As I am not acquainted with any work in which full and accurate statements on the origin and progress of electro-chemical science are to be found, and as some very erroneous statements have been published abroad, and repeated in this country, I shall take the liberty of laying before the Society a short historical sketch on this subject, which is the more wanted, as the Journal in which the early discoveries were registered has long been discontinued, and is now little known or referred to.

"As there are historians of chemistry and astronomy who date the origin of these sciences from antediluvian times, so there are not wanting persons who imagine the origin of electro-chemical science before the discovery of the pile of Volta; and Ritter and Winterl have been quoted *, amongst other per-

* Oersted, translated by Marcel, 1813.

sons, as having imagined or anticipated the relation between electrical powers and chemical affinities before the period of this great invention. But whoever will read, with attention, Ritter's 'Evidence that the Galvanic Action exists in Organised Nature,' and Winterl's 'Prolusiones ad Chemiam Sæculi Decimi Novi *,' will find nothing to justify this opinion. Ritter's work contains some very ingenious and original experiments on the formation and powers of single galvanic circles; and Winterl's some bold, though loose speculative views, upon the primary causes of chemical phenomena; and in the obscurity of the language and metaphysics of both these gentlemen it is difficult to say what may not be found. In the ingenious though wild views, and often inexact experiments of Ritter, there are more hints which may be considered as applying to electro-magnetism than to electro-chemistry; and Winterl's miraculous '*Andronia*' might, with as much propriety, be considered as a type of all the chemical substances that have been since discovered, as his view of the antagonist powers, the acid and basic, can be regarded as an anticipation of the electro-chemical theory. The queries of Newton, at the end of his 'Optics,' contain more grand and speculative views that might be brought to bear upon this question, than any to be found in the works of modern electricians †; but it is very unjust to the experimentalists, who, by the laborious application of new instruments, have discovered novel facts and analogies, to refer them to any such suppositions as, 'that

* Jena, 1800.

† See the eloquent observations of Mr. Chenevix on Winterl's Theory, Annales de Chimie, Cap. L.

all attractions, chemical, electrical, magnetic, and gravitative, may depend upon the same cause;' or to still looser expressions, in which different words are used, and applied to the same ideas, and in which all the phenomena of nature are supposed to depend on the dynamic system, or the equilibrium and opposition of antagonist powers.

"The true origin of all that has been done in electro-chemical science was the accidental discovery of MM. Nicholson and Carlisle, of the decomposition of water by the pile of Volta, April 30. 1800. * These gentlemen immediately added to this capital fact the knowledge of the decomposition of certain metallic solutions, and the circumstance of the separation of alkali on the negative plates of the apparatus. Mr. Cruickshank, in pursuing their experiments, added to them many important new results, such as the decompositions of muriates of magnesia, soda, and ammonia by the pile, and that alkaline matter always appeared at the negative and acid at the positive pole †; and Dr. Henry, about the same time, made some unsuccessful attempts to decompose potassa in solution by the pile, and confirmed the general conclusions of MM. Nicholson, Carlisle, and Cruickshank. In the month of September, in this year, I published my first paper on the subject of galvanic electricity in Nicholson's Journal, which was followed by six others ‡, the last of which appeared in January, 1801. In these papers I showed that oxygen and hydrogen were evolved from separate portions of water, though vegetable and even animal substances

* Nicholson's Journal, vol. iv. p. 183.
† Ibid. vol. iv. p. 190.
‡ Ibid. pp. 275. 326. 337. 380. 394.

intervened; and, conceiving that all decompositions might be polar *, I electrised different compounds at the different extremities, and found that sulphur and metallic substances appeared at the negative pole, and oxygen and azote at the positive pole, though the bodies furnishing them were separate from each other. In the same series of papers I established the intimate connection between the electrical effects and the chemical changes going on in the pile, and drew the conclusion of the dependence of one upon the other. In 1802, I proved that galvanic combinations might be formed from single metals, or charcoal and different fluids, chiefly acid and alkaline, and that the side or pole of the conducting substance in contact with the alkali was positive, and that in contact with the acid negative; and, in the same year, I published, that when two separate portions of water, connected by moist bladder or muscular fibre were electrised, nitro muriatic acid appeared at the positive and fixed alkali at the negative pole. † In the same year, Dr. Wollaston placed the identity of the cause of galvanism and electricity, which had been always maintained by Volta, out of all doubt, by some very decisive experiments.

"In 1804, MM. Heisenger and Berzelius stated, that neutro saline solutions were decomposed by electricity, and the acid matter separated at the positive and the alkaline matter at the negative poles; and they asserted, that in this way muriate of lime might be decomposed; and drew the conclusion, that nascent hydrogen was not, as had been generally

* Journal of the Royal Institution, 1802, first series.

† Ibid.

believed, the cause of the appearance of metals from metallic solutions.

" These valuable observations ought to have explained, distinctly, the source of the appearance of acid and alkaline substances at the two extremities of the pile, yet the paper was never translated into English, nor at all attended to; and one of the facts was contradicted by the assertion of, generally a very accurate observer, Mr. Cruickshank, who, in his early experiments, mentioned that he had not been able to decompose muriate of lime in the circuit.

" In 1805, various statements were made, both in Italy and England, respecting the generation of muriatic acid and fixed alkali from pure water. The fact was asserted by MM. Pachioni and Peele, and denied by Dr. Wollaston, M. Biot, and the Galvanic Society at Paris. Mr. Sylvester, who conducted his experiments with some care, stated that if two separate portions of water were electrised out of the contact of substances containing alkaline or acid matter, acid and alkali were generated; so that, up to this time, the question whether these substances were liberated from their combinations, or formed from their elements by electricity, could not be considered as decided; a circumstance not so much to be wondered at, when the novel and extraordinary nature of the whole class of galvanic phenomena is considered.

" It was in the beginning of 1806* that I attempted the solution of this question; and, after some months' labour, I presented to the Society the dissertation to which I have referred in the beginning of this lecture. Finding that acid and alkaline substances, even

* Phil. Trans. 1807.

when existing in the most solid combinations, or in the smallest proportions in the hardest bodies, were elicited by voltaic electricity, I established that they were the results of decomposition, and not of composition or generation; and, referring to my experiments of 1800, and 1801, and 1802, and to a number of new facts, which showed that inflammable substances, and oxygen, alkalies, and acids, and oxidable and noble metals, were in electrical relations of positive and negative, I drew the conclusion that *the combinations and decompositions by electricity were referable to the law of electrical attractions and repulsions;* and advanced the hypothesis, '*that chemical and electrical attraction were produced by the same cause, acting in one case on particles, in the other on masses;*' and *that the same property, under different modifications, was the cause of all the phenomena exhibited by different voltaic combinations.*"

Here it is necessary to pause. The dissertation just alluded to was his first Bakerian Lecture "On some Chemical Agencies of Electricity," read to the Royal Society in 1806, which M. Berzelius calls "un rapport qui doit être rangé parmi les meilleurs memoires dont on ait jamais enrichi la théorie de la chimie *," which Dr. Thompson says "constitutes one of the most important contributions ever made to scientific chemistry †; and for which, during a period of the most sanguinary war ever waged between England and France, a prize, founded by Napoleon for the most important discoveries in

* Traité de Chimie, par J. F. Berzelius; traduit par J. F. Jourdan. Paris, 1829. Vol. i. p. 164.

† An Outline of the Sciences of Heat and Electricity, by T. Thompson, M.D., p. 535.

galvanism, was awarded its author by the Institute of France.

If I may venture to express myself respecting this lecture, I would say that it is a striking instance of experimental and inductive philosophy, not less distinguished for caution and doubt in relation to what was doubtful, and for patience and ingenuity in investigating the sources of error, than for quickness in perceiving truth, and boldness in embracing it. And I would add, the results are an excellent example of the fruits of this philosophy; not useless combinations of words, mere opinions, such as are derived from speculation, but new facts and principles; and, in brief, a power gained, — a new science, electro-chemistry, — which was to become a means for the further extension of science, and for discovering new and extraordinary facts.

His own manner of considering electro-chemistry, in regard to speculation, was very characteristic of him. Not blinded by the brilliancy of the prospect of the apparent identity of electrical and chemical attraction, and not tempted beyond the bounds of a sound logic by the remarkable discoveries which he made in conformity with this view, he always considered it an hypothesis. Thus he spoke of it in his first Bakerian Lecture, and thus also in his last, when vindicating his claims to originality. I shall quote the passage, especially for the sake of the vindication: —

"Believing that our philosophical systems are exceedingly imperfect (he says), I never attached much importance to this hypothesis (*that chemical and electrical attraction were produced by the same cause, acting in one case on particles, in the other on masses*); but having formed it after a copious induction of

facts, and having gained immediately by the application of it a number of practical results, and considering myself as much the author of it as I was of the decomposition of the alkalies, and having developed it in an elementary work, as far as the present state of chemistry seemed to allow, I have never criticised or examined the manner in which different authors have adopted or explained it; contented if, in the hands of others, it assisted the arrangements of chemistry, or mineralogy, or became an instrument of discovery. And having now given (he continues) what, I believe, to be a faithful sketch of its origin, I shall not enter into an examination of those works which have induced me to make this sketch, and which contain partial or loose statements on the subject, and which refer the origin of electro-chemistry to Germany, Sweden, and France, rather than to Italy or England, and which attribute some of the views of the science which I first developed to philosophers, who have never made any claim of the kind, and who never could have made any, as their works on the subject were published many years after 1806." *

This clear statement of facts, it might have been supposed, would have carried conviction along with it, and would have set the question of originality respecting this subject for ever at rest. But it has not had this effect altogether; and very lately, in more than one instance, men of science, and even his countrymen, forgetful of his labours, in describing the progress of chemical discovery, and the developement of electro-chemistry, have brought forward the names of

* Phil. Trans. 1826, p. 390.

Heisenger and Berzelius as the discoverers of the electro-chemical principles, passing by entirely him by whom they were, in reality, firmly established. Even Berzelius himself, I regret to see, in a recent work, has exposed himself to the same charge. Speaking of the pretended formation of acid and alkali in water, acted on by the voltaic battery, he says, "Dans une série d'expériences que je fis avec Heisenger, et que nous publiâmes en 1803, nous parvînmes à démontrer la véritable manière dont les choses se passent dans la prétendue formation d'acide, et d'alkali, et à faire voir que tous ces phénomènes dépendent des lois générales, en vertu desquelles quand la pile se décharge à travers des liquides, les corps combustibles, et les bases salifiables se rassemblent autour du pole négatif, tandis que l'oxigene et les acides vont se réunir à pole positif. Trois ans après Davy répéta ces expériences avec de plus grands appareils, et prouva que cette loi s'applique jusqu'à un dégré dont on n'avoit encore eu aucun soupçon." * The truth is, that my brother's researches in 1806 were made quite independent, and without any knowledge of the observations of the Swedish philosophers, as he states, in alluding to them in his historical notice. He says, "These observations were never quoted by any writer of the day on the pretended formation of muriatic acid and alkali; and I was not acquainted with them till after my fundamental experiments were finished; and when, in drawing up an account of them, I looked back through the whole series of periodical publications to find accounts of experiments bearing upon

† Traité de Chimie, par J. J. Berzelius, vol. i. p. 166. Paris, 1831.

the same question, and I believe I first directed the public attention to the value of these researches." *

The Bakerian Lecture of 1806 owed nothing to the labours of these gentlemen, and it would have been in every respect as complete had they never been published; but had this lecture been suppressed, a vast accession of knowledge would have been lost to the world. Electro-chemical science might never have been developed; and all the discoveries and great advances in chemistry which followed might never have been made.

Unless honour is bestowed with a strict justice and love of truth, the interests of science must suffer, and one of the strongest motives to scientific exertion — the love of honest fame — will be sapped and destroyed.

* Phil. Trans. 1826, p. 388. note.

CHAPTER VI.

SKETCH OF HIS SCIENTIFIC PURSUITS CONTINUED. — EXPERIMENTS ON ASTRINGENT VEGETABLES AND TANNING. — HIS ATTENTION TO AGRICULTURE, AND AGRICULTURAL RESEARCHES. — IS APPOINTED PROFESSOR TO THE BOARD OF AGRICULTURE. — NOTICE OF HIS ELEMENTS OF AGRICULTURAL CHEMISTRY. — HIS GEOLOGICAL VIEWS IN CONNECTION WITH ELECTRO-CHEMISTRY. — OTHER SCIENTIFIC LABOURS. — EXTRACTS FROM HIS NOTE BOOKS OF THIS PERIOD, IN VERSE AND PROSE, ON VARIOUS SUBJECTS.

My brother's other researches during this period now require consideration.

Soon after his arrival at the Royal Institution, at the suggestion and by the desire of the managers, he gave his attention to tanning, with a view to the improvement of the practical part of the art. He entered upon the investigation with all his usual ardour; visited tan-yards, cultivated the acquaintance of practical tanners (in one of whom, Mr. Purkis, he had the good fortune to find a sincere friend, as well as an enlightened man), and made a large number of experiments in the laboratory. Indeed, the interest he took in the pursuit could hardly have been keener had he made it his profession. This is expressed in a lively manner in the following passage of a letter to my mother. He says, "I saw Mr. William Bolitho and his two brothers-in-law yesterday, and they breakfast with me to-morrow. We are all fellows of the same craft; they are great practical tanners, and I am a theoretical one. By the bye, I have ascertained some facts relating to tanning, which I hope will be really useful."

The results of his inquiries in a collected form he communicated to the Royal Society in 1803, and they were published in the Philosophical Transactions for that year, with the title of "An Account of some Experiments and Observations on the Constituent Parts of certain Astringent Vegetables, and on their Operation in Tanning." It is a paper of much labour and minute research, and well deserving the notice, both of the scientific tanner, and of the chemical student entering upon the subject of animal and vegetable chemistry, and the application of them to the arts.

In this inquiry, directed to the improvement of a very lucrative art, as in all his other inquiries, he appears to have had no view to profit, to have been under the influence of no mercenary motive, and to have been perfectly satisfied with the pure rewards of science, — an increase of knowledge and reputation, and power of being useful. One present, I believe, he had, not indeed in acknowledgment, but in proof of the able aid he gave the practical tanner; which was a pair of shoes, one made of leather tanned by oak bark, in the old way, and the other by catechu, which he wore with much satisfaction, the catechu leather (the first that had ever been made) proving not inferior in quality to the oak-bark leather.

About the same time that he entered upon the investigation of tanning, he also turned his attention particularly to agricultural chemistry, and made it the subject of experimental research; and such was the rapidity of his progress in this inquiry, that in 1802 he was solicited and engaged by the Board of Agriculture to deliver a course of lectures to its members "On the Connection of Chemistry with Vegetable Physiology."

His rapid advance in the science of agriculture, for so it may be called in connection with chemistry, is more surprising in appearance than in reality, and is not difficult of explanation. Even from childhood he was familiar with all the ordinary operations of farming; and probably even before he commenced the study of chemistry, an interest had been excited in his mind towards agriculture, and he had become an observer. His father, as already noticed, was of a speculative turn of mind, and fond of farming and gardening. He did not confine himself to routine methods in either, but made trials of new methods. Amongst other experiments of his, of which I have heard mention, was one of watering grass meadows slightly with sea water, the result of which appears to have been favourable. Trials of this kind could not fail to have excited my brother's curiosity. Moreover, the region in which he spent his early youth was well adapted to keep alive and to heighten this feeling. The shores of the Mount's Bay and the adjoining country exhibit an extraordinary variety of surface, and some very striking contrasts of appearance of barrenness and of fertility. There, in a very small space, may be witnessed, within view of each other, the moving sand, the stagnant marsh, the grass meadow, corn-field, orchard, garden, and heat-hcovered moor, with almost every variation of soil capable of being produced by intermixture of the clays resulting from the decomposition of granite, and the disintegration of killas with sea-sand, and the siliceous detritus of primitive rocks. In the same little space may be witnessed on one side the fertilising effects of substances derived from the sea, as shell-sand, sea-weed, and decayed fish, used as a manure;

and, on the other side, the sterility consequent on the operations of mining, and how the products of the mines, in different forms, are poisonous to, and destructive of vegetation, whether in the state of rubbish scattered over the ground, or collected in heaps on the site of the mine appropriately called "deads," or suspended or dissolved in water, impregnating the adjoining streams, or rising in fume and vapour in the operation of the extraction of tin and copper from their ores. The fertilising influence of one set of causes, and the deleterious effects of the other, are so well marked, that they must necessarily arrest the attention; and, to a person tolerably well conversant with the principles of chemistry, they are no mean elements for agricultural chemistry. When he left his native country, circumstances continued favourable for preserving in his mind a lively interest in agriculture—circumstances both of time and place. In relation to the latter, it is scarcely necessary to make any remark. In the rich valleys of the Severn and Avon, contrasted with the generally barren surface of Cornwall, he must have seen a striking exemplification of the productive powers of soil; and in the more enlightened system of husbandry, then coming into use in the midland counties of England, especially as regards rotation of crops, compared with the old fallow system, which still maintained its ground in his native county, he must have seen as strongly exemplified the resources of science, and its superiority over prejudiced and traditional art. This period of time was a very peculiar and critical one; enhancing the value of agriculture, and demonstrating its truly vital importance to the nation. A succession of bad harvests, and the closure of the

ports of the Continent, in consequence of the war, together threatening famine, gave rise to unwonted exertions to oppose and prevent the apprehended evil, which were rewarded with eminent success, and afforded convincing proof of the capacity of improvement of our agricultural resources.

This was the exact period when his attention was called to the subject, when there was an unusual avidity for information; an unusual disposition to make new trials, and adopt new methods; and to endeavour to convert farming, from a mere art of blind processes, which it was, and is still, too generally, into a rational system of science. And he was invited to promote this good cause by a body of the most enlightened and influential agriculturists of the country, who constituted the Board of Agriculture, and who exerted themselves, in a very spirited and patriotic manner, to collect and diffuse useful knowledge throughout the country.

The manner in which he followed his inquiries into agricultural chemistry was, as well as his object, very similar to that he employed in investigating the art of tanning; viz., the illustrating and improvin the methods of art, by applying to them the principles of science. He witnessed and studied the operations of the practical farmer; he made himself acquainted with the various methods of agriculture; he reasoned on these, and made them the subjects of experiment; he examined different kinds of soil, ascertained their physical properties and chemical compositions; and investigated experimentally the nature of manures, and their effects in different states.

The results of these inquiries he communicated to the Board of Agriculture in the lectures which,

for ten years successively, he delivered at its meetings; and which, when he ceased to lecture in 1813, he published at the request of the Board, with the title of "Elements of Agricultural Chemistry, in a Course of Lectures for the Board of Agriculture."

The style of these lectures is different from that which he adopted in addressing a mixed audience in the theatre of the Royal Institution; it is almost without ornament, perspicuous and simple. Its object was rather to give information than to excite feeling: his hearers were fully impressed with the importance of the subject, and required no persuasion to take a lively interest in it.

To give a faithful idea of the work, it would be necessary to enter into a minute analysis of it, which I do not consider suitable to my undertaking. My notice of it must be partial, and confined to what is most remarkable in it, and most original.

The first who ever attempted, in England, to convey instruction by means of lectures on agricultural chemistry, or to form into a system of science the disjointed information which had been gradually accumulating, he was perfectly free to follow that plan which he might consider best adapted to the views he proposed to inculcate, and the knowledge which he had to communicate.

The manner in which he treated the subject was very general: — "Agricultural chemistry," he says, "has for its objects all those changes in the arrangements of matter connected with the growth and nourishment of plants; the comparative values of their produce as food; the constitution of soils; the manner in which lands are enriched by manure, or rendered fertile by the different processes of cul-

tivation." And he adds, "Inquiries of such a nature cannot but be interesting and important, both to the theoretical agriculturist, and the practical farmer. To the first, they are necessary in supplying most of the fundamental principles on which the theory of the art depends; to the second, they are useful in affording simple and easy experiments for directing his labours, and for enabling him to pursue a certain and systematic plan of improvement." This he illustrates by some appropriate instances, which I shall quote, as affording a good specimen of the style of composition he adopted in these lectures, and of the powers of chemistry, in connection with agriculture: —

"It is scarcely possible to enter upon any investigation in agriculture without finding it connected, more or less, with doctrines or elucidations derived from chemistry.

"If land be unproductive, and a system of ameliorating it is to be attempted, the sure method of obtaining the object is, by determining the cause of its sterility, which must necessarily depend upon some defect in the constitution of the soil which may be easily discovered by chemical analysis.

"Some lands of good apparent texture are yet sterile in a high degree; and common observation and common practice afford no means of ascertaining the cause, or of removing the effect. The application of chemical tests in these cases is obvious; for the soil must contain some noxious principle, which may be easily discovered, and probably easily destroyed.

"Are any of the salts of iron present? they may be decomposed by lime. Is there an excess of silicious sand? the system of improvement must depend on the application of clay and calcareous

matter. Is there a defect of calcareous matter? the remedy is obvious. Is an excess of vegetable matter indicated? it may be removed by liming, paring, and burning. Is there a deficiency of vegetable matter? it is to be supplied by manure.

"A question concerning the different kinds of limestone to be employed in cultivation often occurs. To determine this fully, in the common way of experience, would demand a considerable time, perhaps some years, and trials which might be injurious to crops; but, by simple chemical tests, the nature of a limestone is discovered in a few minutes, and the fitness of its application, whether as a manure for different soils, or as a cement, is determined.

"Peat earth, of a certain consistence and composition, is an excellent manure; but there are some varieties of peats which contain so large a quantity of ferruginous matter as to be absolutely poisonous to plants. Nothing can be more simple than the chemical operation for determining the nature and the probable uses of a substance of this kind.

"There has been no question on which more difference of opinion has existed than that of the state in which manure ought to be ploughed into the land; whether recent, or when it has gone through the process of fermentation; and this question is still a subject of discussion: but whoever will refer to the simplest principles of chemistry, cannot entertain a doubt on the subject. As soon as dung begins to decompose, it throws off its volatile parts, which are the most valuable and most efficient. Dung which has fermented, so as to become a mere soft cohesive mass, has generally lost from one third to one half of its most useful constituent elements. It evidently

should be applied as soon as fermentation begins, that it may exert its full action upon the plant, and lose none of its nutritive powers.

It would be easy to adduce a multitude of other instances of the same kind; but sufficient, I trust, has been said to prove that the connection of chemistry with agriculture is not founded in mere vague speculation, but that it offers principles which ought to be understood and followed, and which, in their progression and ultimate results, can hardly fail to be highly beneficial to the community."

The cautious and practical, and, I may add, philosophical, tone of mind in which he entered upon his subject, and recommended in the investigation of it, may be judged of by the following extracts: —

"No general principles can be laid down respecting the comparative merit of the different systems of cultivation, and the different systems of crops adopted in different districts, unless the chemical nature of the soil, and the physical circumstances to which it is exposed, are fully known. Stiff coherent soils are those most benefited by minute division and aëration; and in the drill system of husbandry these effects are produced to the greatest extent: but still the labour and expense connected with its application, in certain districts, may not be compensated for by the advantages produced. Moist climates are best fitted for raising the artificial grasses, oats, and broad-leaved crops; stiff aluminous soils, in general, are most adapted for wheat crops; and calcareous soils produce excellent sainfoin and clover.

"Nothing is more wanting in agriculture than experiments, in which all the circumstances are mi-

nutely and scientifically detailed. This art will advance with rapidity in proportion as it becomes exact in its methods. As, in physical researches, all the causes should be considered, a difference in the results may be produced, even by the fall of a half an inch of rain more or less in the course of a season, or a few degrees of temperature, or even by a slight difference in the subsoil, or in the inclination of the land.

"Information collected, after views of distinct inquiry, would necessarily be more accurate, and more capable of being connected with the general principles of science; and a few histories of the results of truly philosophical experiments in agricultural chemistry would be of more value in enlightening and benefiting the farmer, than the greatest possible accumulation of imperfect trials conducted merely in the empirical spirit. It is no unusual occurrence, for persons who argue in favour of practice and experience, to condemn generally all attempts to improve agriculture by philosophical inquiries and chemical methods. That much vague speculation may be found in the works of those who have lightly taken up agricultural chemistry, it is impossible to deny. It is not uncommon to find a number of changes rung upon a string of technical terms, such as oxygen, hydrogen, carbon, and azote, as if the science depended upon words rather than upon things. But this is, in fact, an argument for the necessity of the establishment of just principles of chemistry on the subject. Whoever reasons upon agriculture, is obliged to recur to this science. He feels that it is scarcely possible to advance a step without it; and if he is satisfied with insufficient views, it is not because he prefers them to accurate knowledge, but, generally, because they are

more current. If a person journeying in the night wishes to avoid being led astray by the ignis fatuus, the most secure method is to carry a lamp in his own hand. It has been said, and, undoubtedly, with great truth, that a philosophical chemist would most probably make a very unprofitable business of farming; and this certainly would be the case, if he were a mere philosophical chemist; and unless he had served his apprenticeship to the practice of the art, as well as to the theory. But there is reason to believe that he would be a more successful agriculturist than a person equally uninitiated in farming, but ignorant of chemistry altogether; his science, as far as it went, would be useful to him. But chemistry is not the only kind of knowledge required: it forms a part of the philosophical basis of agriculture; but it is an important part, and, whenever applied in a proper manner, must produce advantages.

"In proportion as science advances, all the principles become less complicated, and consequently more useful; and it is then that their application is most advantageously made to the arts. The common labourer can never be enlightened by the general doctrines of philosophy; but he will not refuse to adopt any practice, of the utility of which he is fully convinced, because it has been founded on these principles. The mariner can trust to the compass, though he may be wholly unacquainted with the discoveries of Gilbert on magnetism, or the refined principles of that science developed by the genius of Æpinus. The dyer will use his bleaching liquor, even though he is, perhaps, ignorant not only of the constitution, but even of the name, of the substance on which its powers depend. The great purpose of

chemical investigation in agriculture ought, undoubtedly, to be the discovery of improved methods of cultivation. But, to this end, general scientific principles and practical knowledge are alike necessary. The germs of discovery are often found in rational speculations, and industry is never so efficacious as when assisted by science."

As we have seen from his definition of agricultural chemistry, he allowed himself the greatest possible latitude in treating of it, convinced that it was only by a comprehensive view of his subject that he should be able to render it interesting and useful : and this remark I would offer in reply to those critics who have been of opinion that he unnecessarily associated agricultural chemistry with vegetable physiology, as if there were no natural connection between them, and that the alliance was injurious.* As well, it appears to me, might it be attempted to teach animal chemistry without reference to physiology. Both in vegetable and animal life, functions are the subjects of most importance ; and in the one, as well as in the other, they can only be successfully investigated by calling in the aid of chemistry. The little that has been ascertained in a satisfactory manner, both in animal and vegetable physiology, has in great part been owing to chemistry ; and there is good reason to believe, that no very extensive improvement or advance in the former can take place unpreceded by the advancement of the latter. Many instances might be given in corroboration ; one may suffice, in which, by a simple experiment, a very important fact is almost demonstrated ; viz., that plants derive their

* Dr. Paris's "Life," &c., Edin. Review, vol. xxii.

nourishment solely from fluids, and are incapable of absorbing any solid matter, however finely divided :—

"The pores in the fibres of the roots of plants are so small, that it is with difficulty they can be discovered by the microscope; it is not, therefore, probable that solid substances can pass into them from the soil. I tried an experiment on this subject: some impalpable powdered charcoal, procured by washing gunpowder, and dissipating the sulphur by heat, was placed in a phial containing pure water, in which a plant of peppermint was growing; the roots of the plant were pretty generally in contact with the charcoal. The experiment was made in the beginning of May, 1805; the growth of the plant was very vigorous during a fortnight, when it was taken out of the phial; the roots were cut through in different parts; but no carbonaceous matter could be discovered in them, nor were the smallest fibrils blackened by charcoal, though this must have been the case had the charcoal been absorbed in a solid form. No substance is more necessary to plants than carbonaceous matter; and if this cannot be introduced into the organs of plants except in a state of solution, there is every reason to suppose that other substances less essential will be in the same case."

Of every work of any magnitude, the different parts must almost of necessity vary in interest and importance: such an inequality exists in these lectures. The parts of minor interest are those relating to vegetable physiology; the anatomy, or natural structure, of plants; their proximate principles, their elements, and the general powers of matter by which they are influenced, and the laws according to which they combine and are arranged. These discussions

are merely subservient and auxiliary to the main subject. The most important parts are those which treat of the nature of soils, their analysis, and their improvement; of the nature of manures, their varieties, and the general principles of their use; the manner in which they act, and in which they should be prepared; and, lastly, of the effects of the operations of agriculture, which have for their ostensible object the improvement of the quality of land, or the amelioration of crops; such as burning, irrigation, fallowing, and the system of convertible husbandry.

In all these subjects chemistry bears powerfully on agriculture; and the author applies chemical science with much felicity to their explanation.

By easy processes of analysis, he shows how the three or four earthy elements, of which the majority of soils are composed, may be ascertained; and also the proportion of animal and vegetable matter, and of water, which are essential to all fertile soils. This subject of the analysis and composition of soils first had his attention when he commenced his inquiries in agricultural chemistry. In 1805, he published in Nicholson's Journal a paper on it; and the methods he then recommended have since been copied into most elementary works of chemistry; and they are identically those contained in this work. His object was to give to the agriculturist the power of ascertaining the chemical nature of any soil for practical purposes; and his methods are so simple as to be perfectly attainable by any person of ordinary capacity. In the paper already mentioned, alluding to trials of soils, he makes some remarks which are deserving of being repeated; affording encouragement to the novice in experimental research, and pointing

out the advantages of it, and even the advantages of the failure of experiments : —

"In the first trials that are made, by persons unacquainted with chemistry, they must not expect much precision of result. Many difficulties will be met with ; but, in overcoming them, the most useful kind of practical knowledge will be obtained ; and nothing is so instructive in experimental science as the detection of mistakes. The correct analyst ought to be well grounded in chemical information ; but, perhaps, there is no better mode of gaining it, than that of attempting original investigations. In pursuing his experiments, he will be continually obliged to learn from books the history of the substances he is employing or acting upon ; and his theoretical ideas will be more valuable, in being connected with practical operation, and acquired for the purpose of discovery."

In discussing the subject of manures, he constantly has recourse to scientific views, and endeavours to render what is obscure and mysterious, clear and rational, by means of reference to a few principles, partly physiological, partly chemical. The physiological principle has been already noticed, and the experiment in proof of it. The principle is, that, as plants can draw up only fluids by their roots, solution is an essential circumstance to the activity of manures : —"The great object in the application of manure, should be, to make it afford as much soluble matter as possible to the roots of the plant, and that in a slow and gradual manner, so that it may be entirely consumed in forming its sap and organised parts."* And with this rule is connected the che-

* "Elements of Agricultural Chemistry," p. 273.

mical principles of his theory; viz., that the fermentation of manures necessary for the solution of their insoluble parts, should be a regulated process; and, as it is connected with decomposition, and the escape and loss of gaseous elements, it should be stopped as soon as the end for which it is instituted is attained, or should be carried on underground, and in the act be rendered subservient to the purpose intended — the nourishment of plants.

In confirmation of his views, he gives an account of an experiment, which I shall quote, as a good example of chemical illustration. It is brought forward in proof of the great and injurious loss sustained by the manure of the farm-yard, during the violent fermentation into which it is generally allowed to pass to become what is called *short muck*: —

"In October, 1808, I filled a large retort, capable of containing three pints of water, with some hot fermenting manure, consisting principally of the litter and dung of cattle: I adapted a small receiver to the retort, and connected the whole with a mercurial pneumatic apparatus, so as to collect the condensible and elastic fluids which might rise from the dung. The receiver soon became lined with dew, and drops began, in a few hours, to trickle down the sides of it. Elastic fluid, likewise, was generated: in three days, thirty-five cubical inches had been formed, which, when analysed, were found to contain twenty-one cubical inches of carbonic acid: the remainder was hydrocarbonate, mixed with some azote, probably no more than existed in the common air in the receiver. The fluid matter collected in the receiver, at the same time, amounted to nearly half an ounce: it had a saline taste, and a disagreeable

smell, and contained some acetate and carbonate of ammonia.

"Finding such products given off from fermenting litter, I introduced the beak of another retort, filled with similar dung, very hot at the time, in the soil, amongst the roots of some grass in the border of the garden; in less than a week a very distinct effect was produced on the grass: upon the spot exposed to the influence of the matter disengaged in fermentation, it grew with much more luxuriance than the grass in any other part of the garden."

The application which he makes of the theory of manures, whether to the economy of the farm-yard, for the preparation and the preserving of compound manures, or to the economy of nature, is a striking instance both of the utility and beauty of science, and how it equally tends to render vile things useful, and mean things dignified. I shall quote the last application, with which he concludes the lecture on vegetable and animal manures: —

"The doctrine," he says "of the proper application of manures from organised substances offers an illustration of an important part of the economy of nature, and of the happy order in which it is arranged.

"The death and decay of animal substances tend to resolve organised forms into chemical constituents; and the pernicious effluvia disengaged in the process seem to point out the propriety of burying them in the soil, where they are fitted to become the food of vegetables. The fermentation and putrefaction of organised substances in the free atmosphere, are noxious processes: beneath the surface of the ground, they are salutary operations. In this case the food of plants is prepared where it can be used; and that

which would offend the senses and injure the health, if exposed, is converted, by gradual processes, into forms of beauty and usefulness. The fetid gas is rendered a constituent of the aroma of the flower, and what might be poison becomes nourishment to animals and to man."

The manner in which he treats of fossil manures, and deduces the principles of their operation, — that "they must produce their effect either by becoming a constituent part of the plant, or by acting upon its more essential food, so as to render it more fitted for the purposes of vegetable life," — may be mentioned as a happy example of the union of physiology and chemistry. By means of electro-chemical research, that published in his first Bakerian Lecture, he showed, that distilled water, apparently pure, is not really so; and that various substances, in very minute quantities, may be extracted from it under the influence of the voltaic battery. This fact he employs to refute the conclusion of some physiologists, founded on fallacious experiments, that the earthy and saline parts of plants are formed from air or water, in consequence of the agencies of the living organs.

The fossil manure he first considers is lime, the one most commonly used, and the most important of all of them. Injurious, in the form of quick-lime, to vegetation, he is of opinion that it is beneficial, by accelerating the decomposition and promoting the solution of any hard vegetable matter in the soil.* "Quick-

* He is also of opinion that it promotes the fermentation of vegetable matter. The results of some experiments, which I have made with much care, are in opposition to this idea. In close vessels, I find lime in substance arrests equally vinous fermentation, and the putrefactive, and that it is, in fact, a most powerful antiseptic. Its solvent power is

lime, when it becomes mild, operates in the same manner as chalk, improving the texture of the soil (or its relation to absorption); but, in the act of becoming mild, it prepares soluble out of insoluble matter." And on this simple principle he lays down rules for its use; noting precisely the circumstances in which lime, in its caustic, and also in its mild or carbonated state, should be employed.

He applies the same principle to explain the effects of burnt magnesian limestone, which is a mixture of lime and magnesia; accounting for the well known fact, that the mixture is more active than lime alone, and requires to be laid on in smaller quantity, by the circumstance that magnesia, like lime, is injurious when caustic, and that it remains caustic longer than lime.

The action of two other fossil manures, combinations of lime,—viz., gypsum, in which it is combined with sulphuric acid, and "the earth of bones," in which it is combined with the phosphoric acid, — he explains, on the idea that these two substances enter into the composition of vegetables, the growth of which they promote, — gypsum, in certain of the grasses, and phosphate of lime, in certain of the ceralia; and that they are beneficial as manures, when the earth is destitute of them. In some instances they have been employed, and have apparently failed, the crops not having been improved by the application: in all these cases of apparent

distinct from this. I have found it, contrary to the common belief, very efficient in preserving animal textures, with the exception of cuticle, on which it acts in a peculiar manner, and, from what I have observed, I have very little doubt it might be well employed in preserving rich manures.

failure, he supposes that a fresh supply was not required; that there pre-existed in the soil a sufficient quantity; and whenever he examined the soil the result confirmed the idea.

The manner in which he explains the effects of wood ashes as a manure, is a good illustration of his theory of the action of fossil manures generally: —

"Wood ashes consist principally of the vegetable alkali united to carbonic acid; and, as this alkali is found in almost all plants, it is not difficult to conceive that it may form an essential part of their organs. The general tendency of the alkalies is to give solubility to vegetable matters; and, in this way, they may render carbonaceous and other substances capable of being taken up by the tubes in the radicle fibres of plants. The vegetable alkali, likewise, has a strong attraction for water; and, even in small quantities, may tend to give a due degree of moisture to the soil, or to other manures; though this operation, from the small quantities used, or existing in the soil, can be only of a secondary kind."

In the last lecture on the great operations of agriculture, as burning, irrigation, rotation of crops, &c., the information he brings forward, derived from chemistry, displays, in a very striking manner, the connection between agriculture and chemistry; and how advantageously the refined principles of the latter may be employed to guide and elucidate the processes of the former, and as it were give science to art. Let us take, as an instance, his account of the drill husbandry: —

"In the drill husbandry the land is preserved clean by the extirpation of the weeds by hand, and by raising the crops in rows, which renders the de-

struction of the weeds much more easy. Manure is supplied either by the green crops themselves, or from the dung of the cattle fed upon them; and the plants having large systems of leaves are made to alternate with those bearing grain.

"It is a great advantage in the convertible system of cultivation that the whole of the manure is employed, and that those parts of it which are not fitted for one crop remain as nourishment for another. Thus, in Mr. Coke's course of crops, the turnip is the first in the order of succession; and this crop is manured with recent dung, which immediately affords sufficient soluble matter for its nourishment, and the heat produced in fermentation assists the germination of the seed, and the growth of the plant. After turnips, barley with grass seeds is sown; and the land, having been little exhausted by the turnip crops, affords the soluble parts of the decomposing manure to the grain. The grasses, rye grass and clover, remain, which derive a small part only of their organised matter from the soil, and probably consume the gypsum in the manure, which would be useless to other crops; these plants, likewise, by their large system of leaves, absorb a considerable quantity of nourishment from the atmosphere; and, when ploughed in at the end of two years, the decay of their roots and leaves affords manure for the wheat crop: and, at this period of the course, the woody fibre of the farm-yard manure, which contains the phosphate of lime, and the other difficultly soluble parts, is broken down; and, as soon as the most exhausting crop is taken, recent manure is again applied."

He concludes his work with the following remarks: —

"I have now exhausted all the subjects of discussion, which my experience or information has been able to supply, on the connection of chemistry with agriculture.

"I venture to hope that some of the views brought forward may contribute to the improvement of the most important and useful of the arts.

"I trust that the inquiry will be pursued by others; and that in proportion as chemical philosophy advances towards perfection, it will afford new aids to agriculture.

"There are sufficient motives connected both with pleasure and profit to encourage ingenious men to pursue this new path of investigation. Science cannot long be despised by any persons as the mere speculation of theorists; but must soon be considered by all ranks of men in its true point of view, as the refinement of common sense guided by experience, gradually substituting sound and rational principles for vague popular prejudices.

"The soil offers inexhaustible resources, which, when properly appreciated and employed, must increase our wealth, our population, and our physical strength.

"We possess advantages in the use of machinery and the division of labour, belonging to no other nation; and the same energy of character, the same extent of resources, which have always distinguished the people of the British Islands, and made them excel in arms, commerce, letters, and philosophy, apply with the happiest effect to the improvement of the cultivation of the earth. Nothing is impossible to labour, aided by ingenuity. The true objects of the agriculturist are likewise those of the patriot. Men value most what they have gained with effort;

a just confidence in their own powers results from success; they love their country better, because they have seen it improved by their own talents and industry; and they identify with their interests the existence of those institutions which have afforded them security, independence, and the multiplied enjoyments of civilised life."

The manner in which this work has been received, and the number of editions through which it has passed, the translations of it that have been made into almost every European language, are the best proof of its merit, and of the general estimation in which it has been held. That it was far from a perfect work, no one knew better than the author himself. In criticising it in relation to his powers, the circumstances under which it was composed should be taken into account. To agricultural chemistry he devoted only a small part of his time; and that at a period when he was intensely occupied in researches in the laboratory, in a train of experimental inquiry and discovery to which it would be difficult to find a parallel, either in brilliancy or importance. "We feel grateful to him," observes a contemporary writer in the Edinburgh Review, "for having thus suspended for a time the labours of original investigation, in order to apply the principles and discoveries of his favourite science to the illustration and improvement of an art which, above all others, ministers to the wants and comforts of man."* Moreover, at that time, agricultural chemistry had been very little cultivated; no principles had been established; few satisfactory experiments even had been made of a

* Edin. Review, vol. xxii. p. 253.

precise and scientific kind; and, in consequence, he was obliged to draw almost entirely on his own resources. It is not, therefore, surprising that he sometimes adopted an opinion which has since proved to be erroneous, and indulged in speculation which later research has not confirmed. Science is essentially progressive, and it can be perfected only by the labour of many individuals. From this progressive nature of experimental science, the judgment of posterity on this work will probably be somewhat different from that of his contemporaries; and I imagine that, though the most popular of all his productions now, after a while, from being less original, it will be least in request.

In connection with his geological inquiries he instituted very many experiments on the analysis of mineral bodies, abundant proofs of which are given in his geological lectures; but he published little expressly on the subject; only two papers: one of them giving an account of his analysis of Wavelite, and the other describing the use of Boracic Acid, as a substitute for potash, in the analysis of compound minerals. Both these papers appeared in the Philosophical Transactions for 1805. They are not uninteresting in the annals of analytical chemistry, but they do not appear of sufficient importance to require particular notice. His most important contribution to this department of knowledge was contained in his Bakerian Lecture for 1806, "On some Chemical Agencies of Electricity." In the concluding part of this lecture, he makes some very interesting observations on the influence of electro-chemical action in the economy of nature, and especially in the mineral kingdom, the correctness of which has been fully confirmed

by the ingenious researches of M. Becquerel, and other inquirers. I shall quote his remarks:—

"Alterations of electrical equilibrium are continually taking place in nature; and it is probable that this influence in its faculties of decomposition and transference considerably interferes with the chemical alterations occurring in different parts of our system.

"The electrical appearances which precede earthquakes and volcanic eruptions, and which have been described by the greater number of observers of these awful events, admit of very easy explanation on the principles that have been stated.

"Beside the cases of sudden and violent change, there must be constant and tranquil alterations, in which electricity is concerned, produced in various parts of the interior strata of our globe.

"Where pyritous strata and strata of coalblende occur, where the pure metals or the sulphurets are found in contact with each other or any conducting substances, and where different strata contain different saline menstrua, electricity must be continually manifested; and it is very probable that many mineral formations have been materially influenced, or even occasioned, by its agencies.

"In an experiment that I made of electrifying a mixed solution of muriates of irons, of copper, of tin, and cobalt, in a positive vessel, distilled water being in a negative vessel, all the four oxides passed along the asbestos, and into the negative tube, and a yellow metallic crust formed on the wire, and the oxides arranged themselves in a mixed state round the base of it.

"In another experiment, in which carbonate of copper was diffused through water in a state of minute

division, and a negative wire placed in a small perforated cube of zeolite in the water, green crystals collected round the cube, the particles not being capable of penetrating it.

"By a multiplication of such instances, the electrical power of transference may be easily conceived to apply to the explanation of some of the principal and most mysterious facts in geology; and, by imagining a scale of feeble powers, it would be easy to account for the association of the insoluble metallic and earthy compounds containing acids.

"Natural electricity has hitherto been little investigated, except in the case of its evident and powerful concentration in the atmosphere. Its slow and silent operations, in every part of the surface, will probably be found more immediately and importantly connected with the order and economy of nature; and investigations on this subject can hardly fail to enlighten our philosophical systems of the earth, and may possibly place new powers within our reach." *

The preceding were the principal subjects of research to which he applied himself during this active period of his life; but they were not the only ones: — his pursuits were miscellaneous and discursive; and almost every branch of chemistry had more or

* These anticipations have been in part realized, and probably will be wholly confirmed in the progress of research. Conclusive experiments have shown that, equally in the atmosphere and beneath the surface of the earth, electricity is in operation; and its effects in one region as well as in the other, in our present limited state of knowledge of atmospheric and terrestrial changes, are hardly to be calculated as regards the earth. It is not difficult from analogy to imagine that, under its influence, not only minerals may be formed, as my brother supposed, but that even rocks may become crystalline, unaided either by solution or fusion.

less of his attention. This is indicated, in part, by what he published; but more forcibly by his note books.

In meteorology he took considerable interest, and designed several instruments for aiding the study of it; as a photometer, hygrometer, and endiometer. Of his endiometer he gave an account in the journal of the Royal Institution, accompanied by a notice of the results which he had obtained by means of it, in confirmation of the uniformity of composition of the atmosphere in different seasons, and in different situations. It is one of the simplest and most accurate means hitherto invented for ascertaining the proportions of oxygen and azote; being merely a graduated glass tube, and a solution of muriate or sulphate of iron at the minimum of oxidation saturated with nitrous gas. The solution absorbs the oxygen of the portion of atmospheric air brought in contact with it, leaving the azote free.

He continued his inquiries relative to heat and light, as well as electricity, reviewing his early speculations, and correcting them, when not in accordance with the results of carefully conducted experiments. A paper on the collision of steel and hard bodies, bearing on the question of light, he published in the Journal of the Royal Institution.* Most of the facts in it he had ascertained before he left Bristol; and they have been already noticed (page 84.)

In the application of chemistry to the common arts, he did not limit himself to those already considered; namely, agriculture and the art of tanning. Hints occur both in his memoranda and published

* Also in Nicholson's Journal, vol. iv. p. 103.

papers, indicating that he never lost sight of the usefulness of science in relation to our every day wants, even when engaged in researches apparently the least connected with them. He instituted many experiments on the improvement of British spirits; and succeeded, by the admixture of a little etherial oil of wine, in imparting to the spirit distilled from charcoal a flavour very similar to that of Cognac brandy. In his agricultural chemistry he notices the fact; but in a very brief manner, — its interest, with its novelty, having passed away.

In his first "Bakerian Lecture" on some of the chemical agencies of electricity, he suggests a plan for decomposing the neutral salts by means of electricity, and obtaining, with little trouble or expense, their acids and alkalies in large quantities; and, in a memorandum written a year or two previously, he puts the query, "Might not there be an excellent circulating manufactory established for decomposing common salt by boracic acid, and of decomposing borate of soda by lime?"

These things he himself did not try on a large scale with a view to profit: for him discovery had a greater charm than gain; and he appears to have been of opinion, that he had done his duty when he had pointed out the application of a scientific truth or principle to the arts of life; well aware, to use an expression of Lord Bacon's, that "the applying of knowledge to lucre diverts the advancement of knowledge, as the golden ball thrown before Atalanta, which, while she stoops to take up, the race is hindered."

"Declinat cursus, aurumque volubile tollit."

Of all the materials of biography, perhaps, note-books, kept solely for the use of the individual, are the most valuable; they are, as it were, the log-book and register of the mind, and are equally fitted to display its habits and powers. My brother's note-books are not an exception to this remark: hastily written, and irregularly kept, designed for no eye but his own, they are very characteristic of him, and of the pursuits in which he was engaged at the time they were kept. Belonging to this period, his note-books are rather less miscellaneous than those of any former or after time; and principally, though not exclusively, relate to matters of science and philosophy, on which his mind was then most intent. Some selections from them may not be unacceptable to the reader. Of poetry there occurs but little besides what has been already given: two specimens may suffice; one "On Athens," a fragment; the other, "Lines addressed to a Young Lady on her Birthday;" the one pouring forth his admiration of intellect, and the other his love of nature, blended with his love of intellect and beauty. It is right to observe that neither of these effusions appears to have had his attention after they were written; at least I have not been able to find a fair copy of them: —

"TO ATHENS.

"Oh Athens! child of elder glory,
The first, the best, renown'd in story!
From whom, amidst the births of time
Sprang forth, immaculate, sublime,
The love of letters, science glowing,
And an holy charm bestowing
On all the natural forms of things,
Giving to the Muses wings

To raise them from the paths of pleasure,
From orgies in the Lydian measure,
Amidst dark Cyprian vineyards given,
To the eternal light of heaven;
To call them from the thoughts of error,
From superstition's midnight terror,
From the tyrant's gold-bought praise,
From whining parasitic lays,
To intellect's more wholesome food,
The magnificent and good;
From base and popular applause,
From judgment's foul unhallowed laws,
To that which, sacred and refined,
Flows from the eternal mind!
Knowledge that never can decay
(Exhaustless as the unfathom'd sea),
That to the ardent lover gives
That vital dew which each that lives
Absorbs, demands, with joy inhales,
Whether from the peaceful gales
Breathing o'er those happy isles,
Where Nature is profuse of smiles,
Or the keen north, whose fur clad host
Ranged upon the Arctic coast,
Beneath the light of moon and star,
Wait the day-spring from afar,
And in their long and tedious night
In visions catch the solar light.
Athens! the poet's darling theme, —
Athens! the patriot's sacred dream,
Where luxury did a form assume
Which all the virtues might illume,
Where Venus wore Minerva's plume;
Warmed by whose beauteous charms the sage
Was youthful in the vale of age;
Where woman lovely shone, supreme
Above the poet's loftiest dream,
And to philosophy had given
Elysium, and a mortal heaven.
She yielded not to gold alone,
Nor to Golconda's glittering stone:
She loved whatever could expand
The soul, — the beautiful, the grand:
Whatever Phidias had designed
Expressive of immortal mind,
Came to her fancy like the sound
Of mountain torrents murmuring round."

* * * * *

"TO A YOUNG LADY ON HER BIRTHDAY.

"Hail, loved one! to thy natal morn!
May every coming year adorn
Thy mind with new-born charms and powers;
And never may the fleeting hours
Tell thee of aught but happiness!
May Nature, in her fairest dress,
For thee frame flowery chaplets new
Of roses fresh in matin dew!
May every season of the year
For thee some new delight prepare!
In spring mature the rural scenes
Of highland glens or pastoral plains.
There, where the moon in parting day
Sheds through the trees her trembling ray
Upon the balmy moss beneath,
Mayst thou the evening zephyr breathe
And listen to the songs which move
The plumed choristers to love!
Or if the moonshine is not seen,
May glow-worms light thee on the green;
Or the fair star whose tranquil ray
Seems in the solar blaze to play,
As if it fed upon its streams
Of light, and caught its dying beams!
When summer's suns in fervor glow,
Then be thy haunt the mountain's brow,
Where blue, amidst the brilliant sky,
Its giant helms are lifted high
Above the cloudy canopy,
Which spreading like a sea of light
In dappled colours fleecy bright,
(As if a sudden fairy birth)
At once commingle heaven and earth.
When their rich dress the woods display
And quicker wanes the tranquil day,
Then mayst thou haunt the murmuring streams
Fitted for poetic dreams!
Where the cushet's mournful sigh
Tells love's sweet season is gone by;
There mayst thou then in quiet slumbers
Frame some soul-awakening numbers,
Some melancholy musing high,
Breathing of immortality!
When slanting suns through snow clouds peep,
And Nature seems to sink in sleep,
Then may society impart
Its sacred influence to thy heart;

Not the vain influence of the crowd,
Or sneering low, or laughing loud,
But that which from the wise and good
Flows pure as if in solitude! —
Creative, noble, free, and kind,
The light, the spirit of the mind.
And mayst thou, lovely woman! give
Feelings which shall for ever live;
The images by passion caught,
The eloquence which kindles thought,
Which strength to weakness can impart,
And rouse again the exhausted heart;
Like the refreshing streams that flow
From Cotopaxi crowned with snow,
Wakening where Quito's plains expand
Life upon the burning sand,
Creating by their balmy power
The dewy herb and odorous flower!
Oh never may the coming years
Be seen through gloom, or mists of tears,
But tinged with rainbow hues, and bright
As autumn's skies in evening light!
Or if a transient cloud should rise,
Soon may it glow with brilliant dyes;
And, like the clouds that shed the dew,
And give the flowers a brighter hue,
May it a healing charm impart
To soften or to wake the heart!
No grief, no anguish mayst thou prove —
No care, unless it spring from love!" H. D.

On the subject of religion, comparing the Christian with other religions, the following reflections are written in pencil, in a note-book kept in 1805; and it is easy to imagine that they might have been put down after his mind had been warmed by some such discussion relative to religion as that already mentioned as having occurred in Ireland, at Dr. Richardson's: —

"The notions delivered in the early systems of mythology with regard to a future state are vague, obscure, and inadequate. The Cimmerian shades of Homer, or the Elysian fields of Virgil, present no

high impressive pictures; to form them required only a distempered imagination; and the sufferings of the vicious in Tartarus were fitted perhaps to excite a certain degree of superstitious fear in weak minds: but the happiness bestowed on the heroic and the virtuous, in the Elysian shades, is of a nature too feeble and indistinct ever to have had a material influence on spirits of a nobler stamp. The pleasures of the good are represented as the mere shadows of earthly enjoyments; and no justly thinking man living under the system could have sacrificed the earth for the heaven, the present for the future, or have renounced one vicious inclination in consequence of his veneration for Jupiter, or his dread of the wrath of Pluto.

"In the religion of Mahomet, rewards and punishments are strongly and impressively inculcated. But the paradise of the Mussulman is a rude copy of an earthly garden of pleasure. The mere enjoyment of common sensual pleasure is made the ultimate and glorious destiny of the believer and the blessed; and the warrior who has shed his blood in battle in the cause of God and the Prophet, and the dervise whose body has fallen under the discipline of abstinence and continual penance, have each their similar portions of women and wine, and are supposed eternally happy in the society of virgins immortal and undecaying, amidst ever-verdant groves bright with eternal sunshine, and moistened by streams containing a beverage more delicious than the juice of the grape of Schiraz.

"The tendency of such contemplations must necessarily be to debase and enfeeble the character, and to imprint more deeply on the mind the lowest passions,

and the most brutal appetites. That religion which has the harmony of truth, on the contrary, must necessarily curb the senses, and exalt the spirit; and, in all its details, must appeal to the loftiest and most intellectual passions of our nature. In the Christian system, the pleasures as well as the pains of a future life, though inconceivably great, have yet their means and their end concealed in mystery. The indefinite, the strongest source of high interest, is perpetually called up in the mind — 'Eye hath not seen, nor ear heard, neither hath it entered into the heart of man to conceive the joys that he hath prepared for those who love him.' Sublimity is the characteristic of the future state in the religion of Jesus. The highest degree of hope or of fear must be awakened by it. The objects are grand, indefinite; and they are therefore most perfectly calculated to occupy the faculties of a being whose capacity of mental enjoyment and suffering, of improvement and degradation, appears without bounds. Of all the religions which have operated upon the human mind, Christianity alone has the consistent character of perfect truth; all its parts are arranged with the most beautiful symmetry; and its grand effects have been constantly connected with virtuous gratification, with moral and intellectual improvement, with the present and future happiness of man."

This, I may remark, is a fragment, stopping at the commencement of a new sentence, —

"The existence of a Supreme Being," &c.

Relative to the extracts which follow, I need premise but little. Those of greatest length appear as if written in preparation for lectures, whilst the very

short ones may be considered as thoughts noted down to be arrested in passing.

"For the human mind is always governed not by what it knows, but by what it believes; not by what it is capable of attaining, but by what it desires or fears. There had been no demonstration of the impracticability of alchemy. The cultivators of this delusive art were occasionally visited by splendid visions of immortality, of unbounded riches, of inexhaustible pleasures. Even their *failures* developed some unsought-for object partaking of the marvellous. The instruments of their experiments were *new*. They had produced fire from the mixture of cold liquids. They had discovered specifics for formidable diseases. They had dissolved the metals, and had produced from liquid mixtures copper, and silver, and gold. In an age of enthusiasm, it was not to be expected that they themselves should set limits to their powers. At a time when even comparatively enlightened men were believers in witchcraft and its charms; at a time when that science was the chief study which is improperly called metaphysics, and which is founded upon an abuse of words, and a substitution of unmeaning phrases for the names of things; at a period when Aristotle reigned, and was, as it were, a tutelary deity of every professor's chair; at a time when magic was believed,—it could not be expected that the *alchemical professors* should be the reasoning sect of the age. We have seen their errors, and the present generation has gained by their mistakes. They had discoverd a *light* capable of guiding them in that dark night of ignorance, but they mistook their path. The *light*, however, was not extinguished, and it became subservient to

the ends and the views of the chemical philosophers. Let it be remembered that I am speaking of the *speculative alchemists*, such men as Helmont, Helvetius, and Slare; and not of those vain impostors and projectors who made the few secrets of chemistry the means of popular delusion: not of those immoral adventurers who travelled through Europe imposing upon the credulous and the ignorant; promising every thing, performing nothing; pilfering from their dupes, offering them riches, and reducing them to poverty.

"It was the custom of these trading projectors to establish themselves wherever they were unknown; to promise to reveal the art of making the philosopher's stone; to build furnaces; to rob their employers, under the excuse of the necessity of preparation; and, when the time was accomplished beyond which they were unable to deceive, to explode their apparatus, or set fire to the house, and escape in the confusion. It is against the vile sect, common in the days of Queen Elizabeth, that Ben Jonson directed the keen and admirable dramatic satire of 'The Alchemist,' and they were all akin to the projector:—

> 'The doctor — the smoky bearded, — he
> Will close you so much gold in a bolt's head,
> And in a turn convey in the stead another,
> With sublimed mercury that shall mount in the heat,
> And all fly out in fumo.'

"The passions of these men were low, their purposes vile and inglorious. The *true alchemical philosophers*, on the contrary, had often sublime and elevated views. The idea of glory was continually present to them. To ameliorate the condition of humanity, and to support the interests of religion,

were constantly held out as their objects. A spirit of unaffected piety generally animates their works; and faith, charity, and brotherly love characterised their association. Their credulity was the vice of their age; their errors were the errors natural to an infant science; but their industry was unceasing, their *hopes glorious*, and their discoveries eminently useful."

"At that time, when Bacon created a new world of intellect, and Shakspeare a new world of imagination, it is not a question to me which has produced the greatest effect upon the progress of society—Shakspeare or Bacon, Milton or Newton. Shakspeare, indeed, has entered with a power that can never be imitated into all the recesses of the human heart; has given infinite delight to all tastes and all conditions of society, and painted man, and enabled us to understand man. But the influence of these wonderful works is limited by the pleasure that they give; they, undoubtedly, often excite to actions of virtue, but their impression is like that of a dream. The object of poetry, whatever may be said by poets, is more to amuse than to instruct; the object of science more to instruct than amuse.

"Milton, undoubtedly, has given great enjoyment to the imagination by his varied noble and heroical thoughts, and lofty and virtuous sentiments; but his influence has been comparatively little extensive. Different nations have different opinions; the most superb of his ideas cannot with justice be rendered into other languages, and his most exquisite pictures have some connection with locality. And even the taste is variable; the capricious and the mutable

oppose themselves to any standard. The mixed mythology of religion of Tasso is more delightful to some than the pure machinery of Milton; the bewitching paintings of Shakspeare, in which nature appears as it really is, offends the Frenchman, who, in tragedy at least, demands the eternal sententious and powerful declamation, and requires even that the very servants should wear the buskin.

"In natural science there is one language universally intelligible,—the language of facts; it belongs to nature, and it is permanent as the objects of nature; it is the same to the citizen of Paris and London. Whenever the name of Newton is pronounced, it is pronounced with reverence; the name of Englishman derives glory from it: it is scarcely possible to look at the heavens, and read the order which is now visible in them, without a sensation of gratitude to the great discoverer of their laws. With respect to the exertion of talent required in physical science, and in works of imagination, it is very difficult to estimate the comparative power, genius, and ability. The imagination, as it is called, which is merely the vivid but vague association of images with passion, is principally employed in the one; the reason, which is the association of images according to facts observed in nature, is the faculty exerted in the other: but feeling, and force, and strength, are required for both species of exertion. The power of the mind, in the fervour of poetical composition, flows like a mountain torrent,—sparkling, foaming, beautiful and grand; but passing principally over rocks, and nourishing only the solitary tree, or the flowers of its mossy borders. The energy of the understanding employed upon the developement of the truths of na-

ture has a calm and quiet progress; in its motion it is like the navigable river; it bears upon it ships; it waters a fertile country; and what it wants in beauty it possesses in benefit; what is deficient in rapidity is supplied in strength."

"The unequal division of property and of labour, the difference of rank and condition amongst mankind, are the sources of power in civilised life, its moving causes, and even its very soul.

"And in considering and in hoping that the human species are capable of becoming more enlightened and more happy, we can only expect that the different parts of the society should be more intimately linked together by means of philosophy and the arts; that they should act as the children of one parent, with one determinate end, so that no exertion should be lost, no power rendered useless. In this view we do not amuse ourselves with delusive dreams concerning the perfectability of the human species, the annihilation of labour, disease, and even death: but we reason by analogy from simple facts; we consider only a state of human progression, rising out of its present condition; we look for a bright day, of which we already perceive the dawn."

"The union of sentiment and feeling in the different parts of a people is always connected with immense advantages: it forms what may be called the national spirit, which is uniformly the source of happiness and prosperity, of independence and conquering energy."

As in character with this sentiment, I shall insert a portion of a letter which he wrote in August, 1807,

to Mr. Poole, relative to the times and his country:—

"The times seem to me to be less dangerous, as to the immediate state of this country, than they were four years ago. The extension of the French empire has weakened the disposable force of France. Bonaparte seems to have abandoned the idea of invasion: if our government is active, we have little to dread from a maritime war, at least for some time. Sooner or later, our colonial empire must fall in due time, when it has answered its ends. The wealth of our island must be diminished, but the strength of mind of the people cannot easily pass away; and our literature, our science, our arts, and the dignity of our nature, depend little upon external relations. When we had fewer colonies than Genoa, we had Bacons and Shakspeares.

"The wealth and prosperity of the country are only the *comeliness* of the body, the fulness of the flesh and fat; but the spirit is independent of them: it requires only muscle, bone, and nerve, for the true exercise of its functions. We cannot lose our liberty, because we cannot cease to *think;* and ten millions of people are not easily annihilated."

"There is scarcely a more dangerous propensity than that of attempting universal literature; of being able to criticise all modern books. It increases the memory at the expense of the reason; it supplies the graces of conversation, without the labour of thought. When I peruse some of the descriptions of ancient Athens and Rome, I am forcibly reminded of some of the societies of modern London. I seem to see the *parasite* clothed in the robes of the moralist; the

affable *jester* concealed under the gown of the sacred minister of religion. I see men renouncing the dignity of character, and the greatness of reputation — (picture of Athens, that all men were able to quote the modern poets — to tell an entertaining tale). It was *then* that the parasite and the jester assumed those robes which were worn by the moralist, the minister of religion, and the philosopher, and prostituted talents that might have been employed to noble purposes, with the hopes of gaining a smile from the idle and the vicious, and a murmur of applause from the great and luxurious."

"The man of genius always feels more power than he is able to develope. His stores are too copious to be at once poured forth. He requires a great stimulus, and there is no stronger characteristic of superlative talents than their association with a contempt of the popular opinion. By the popular opinion, let it not be understood that I mean the decisions of taste, the general opinion of mankind made venerable by antiquity; but that opinion which is the vague result of caprice, fashion, and imitation — which is affected by novelty and quaintness; that opinion which prevails in literature as in dress,—which can give a momentary effect to the splendid, the brilliant, or seductive."

"We are falling into an error the very reverse of that of our ancestors, who compiled and put together every thing. We, perhaps, neglect facts too much; or at least, except in chemistry, we are not sufficiently attentive to the recording of facts. We are too fond of substituting literature for science, talents for in-

formation, and wit or brilliant elocution for accurate and deep research. Declamation is good where the foundations of science are established, but wretched and hurtful where these foundations are wanting."

"Science is more neglected in this than in any other age: men are too much taken up in attempting to produce the *minor arts*. The philosophical spirit is too much banished from all our forms and all our methods; that spirit which Bacon has characterised as the germ of life in the sciences."

"What is the end of our existence, if it be not to investigate the wonders of—to understand the works of God; to increase in intellectual power; to form the moral law upon an extended view of society; to enjoy the sublime pleasures of reason and imagination? As the eye has been made to be delighted with the forms of beauty, the ear with sweet sounds, has the understanding, the peculiar attribute of man, no objects of delight, no enjoyments? Yes; it is the discovery of *truth*, the contemplation of the universe, the sublime pleasure of understanding that which others fear, and of making friends even of inanimate objects; to look back to the origin of things, and to the fate of our globe; and to consider those laws which create and destroy, and which, acting in infinite space, upon innumerable worlds, display the one intelligence of one mind."

"The grandest as well as the most correct views are those that have been gained by minute observation, and by the application of all the more precise and accurate methods of science."

"The light from the sun is too bright for our organs, till it is reflected from the earth. Divine truth requires to be made human truth before it can be relished by us."

"A man should be proud of honours, but not vain of them."

"That light which at first overpowers our organs becomes, under the influence of habit, the language of the external world; so it is with science."

"The brood of the eagle, like that of the bird of night, is at first dazzled and pained by the light of the sun: the one will not cease to look towards it till they can rejoice in its splendour; but the other uniformly avoid its glorious rays."

"One of the greatest benefits conferred by experimental sciences is, that they have given the true progression to the mind; they have appeared as a work begun, but not perfected. There is no spirit or feeling of imitation in them, which uniformly cramps the best energies of the mind; but one desire for extending them: and *discovery* is the great stimulus to exertion, is the highest stimulus to inquiry; and the title of *discoverer* is the most honourable that can be bestowed on a scientific man."

"The great use of practical science is discovery."

CHAPTER VII.

HIS ELECTRO-CHEMICAL DISCOVERIES. — DECOMPOSITION OF THE FIXED ALKALIES. — DANGEROUS ILLNESS. — EXTRACT OF A LECTURE OF THE REV. DR. DIBDIN EXPRESSIVE OF THE FEELING THEN PREVAILING TOWARDS HIM. — RECOVERY. — VERSES WRITTEN AFTER RECOVERY FROM A DANGEROUS ILLNESS. — CONTINUATION OF HIS SCIENTIFIC LABOURS. — DECOMPOSITION OF THE ALKALINE EARTHS. — EXPERIMENTS ON THE OTHER EARTHS. — SPECULATIONS ON THE NATURE OF VOLCANOES. — RESEARCHES ON AMMONIA. — SPECULATIONS CONCERNING THE ELEMENTS OF BODIES. — DECOMPOSITION OF BORACIC ACID. — RESEARCHES ON MURIATIC AND OXYMURIATIC ACID. — CONCLUSION THAT OXYMURIATIC ACID GAS HAD NEVER BEEN DECOMPOUNDED. — THEORY OF CHLORINE. — CONSEQUENCES IN RELATION TO CHEMICAL SCIENCE AND THE PROGRESS OF DISCOVERY. — RESEARCHES ON FLUORIC ACID. — DISCOVERY OF EUCHLORINE, TELLURATED HYDROGEN, AND OF A NEW COMPOUND OF PHOSPHORUS AND HYDROGEN.

The year 1807, to which the narrative of my brother's life is now brought, was, in his career, an eventful one; and, in the history of chemical science, is an era memorable for the decomposition of the fixed alkalies. Almost immediately on entering on his researches, connected with voltaic electricity, he had sanguine expectations of obtaining very important results. In a note book kept at that time, bearing date August 6. 1800, probably when preparing his first paper on the subject, he writes: —

"I cannot close this notice without feeling grateful to M. Volta, Mr. Nicholson, and Mr. Carlisle, whose experience has placed such a wonderful and important instrument of analysis in my power:" — as if he had a prophetic feeling of the great discoveries he was about to effect by means of it; and it is curious that a query immediately follows respecting potash.

"Query: Would not potash, dissolved in spirits of wine, become a conductor?" And this is succeeded by an account of some experiments on the action of the pile of Volta on ammonia dissolved in water, on a solution of caustic potash, and on muriatic acid. Six years after, we have seen, he delivered his first Bakerian Lecture; and, by a strict induction from the facts of experiments, developed the principles of electro-chemical science, and of the agency of the voltaic battery as an instrument of analysis. He then expresses the hope, that "the new mode of analysis may lead us to the discovery of the *true* elements of bodies, if the materials acted on be employed in a certain state of concentration, and the electricity be sufficiently exalted. For if chemical union," he adds, "be of the nature which I have ventured to suppose, however strong the natural energies of the elements of the bodies may be, yet there is every probability of a limit to their strength; whereas the powers of our artificial instruments seem capable of indefinite increase."

In 1807, in conformity with these views of overpowering chemical attraction by electrical attraction, he instituted a series of experiments on the vegetable alkali; and, after a number of trials, was rewarded with the most brilliant success. He began the investigation, I believe, in September; and on the 19th of November, he delivered his second Bakerian Lecture to the Royal Society, containing the results of it. It was entitled, "On some New Phenomena of Chemical Changes produced by Electricity; particularly the Decomposition of the Fixed Alkalies, and the Exhibition of the New Substances which constitute their Bases; and on the General Nature of Alkaline Bodies."

I must refer the chemical reader who wishes to study this lecture to the Philosophical Transactions for 1807. It is well deserving of careful attention, both for the novelty of the means employed, the magnitude and brilliancy of the results obtained, and the simplicity with which they are described. A contemporary writer considers this paper "as the most valuable in the Philosophical Transactions, since the time when Sir Isaac Newton inserted, in that celebrated collection, the first account of his optical discoveries."*

As more suitable to this place, and as it will probably be more acceptable and interesting to the general reader, I shall give his own account of these discoveries from a manuscript lecture, which he delivered in the theatre of the Royal Institution, part of a course on Electro-Chemical Science, in which he rapidly notices the decomposition of the two fixed alkalies; and the train of reasoning by which he was guided in pursuing and extending the inquiry.

"I stated," he observes, "in former lectures, the experiments which led to the decomposition of all *known* compounds by electricity. From these experiments it immediately became a matter of inquiry, whether the same energetic power might not separate the elements of bodies as yet not decompounded by other means. An agent by which even the firmest aggregation was destroyed, by which stones and rocks were broken down, it was easy to conceive might evolve *new elements;* and, on the electro-chemical theory, the *powers* on which composition depend must be limited; whereas the powers

* Edinburgh Review, vol. xii.

of our artificial instruments were capable of indefinite increase.

"I mentioned that acids are attracted in the voltaic circuit towards the positive side; that such of these as are of known composition contain a great excess of oxygen; and, when they are decomposed by electricity, their inflammable matter always passes to the negative surface, and their oxygen to the positive surface. Now all the bodies of known composition, that passed to the negative surface, were either inflammable, or contained an excess of inflammable matter; such, for instance, are the metals, metallic oxides, and ammonia. It was, therefore, an obvious question, whether *other* bodies, attracted to the same surface, such as the alkalies and alkaline earths, might not be analogous in their nature,—not simple bodies,—and containing inflammable matter. The first substance that I made a subject of experiment was potash, the *vegetable alkali*. Many vague and unfounded notions had been formed of the nature and composition of this body. It had been supposed, by some of the Italian and French chemists, to consist of lime and hydrogen. By others it had been regarded as containing nitrogen. The suspicion strongest in my mind was, that it might consist of phosphorus, or sulphur united to nitrogen; for, as the volatile alkali was regarded as composed of an extremely light inflammable body, hydrogen united to nitrogen, I conceived that *phosphorus* and *sulphur*, much denser bodies, might produce denser alkaline matter; and, as there were no *known* combinations of these with *nitrogen*, it was probable that there might be unknown combinations.

In my first trials on potash I used strong aqueous solutions.

" Dry potash is a nonconductor: I then employed *fused potash;* and, in this instance, inflammable matter was developed.

" EXPERIMENTS.

" Then a piece of potash moistened; and, to my great surprise, I found metallic matter formed.

" *October 6th.*—This matter instantly burnt, when it *touched water* — swam on its surface, reproducing potash.

" In dry oxygen gas, likewise, it burnt into perfectly dry potash.

" INSTANCE.

" Soda was decomposed in the same manner.

" The earths had been suspected by the elder chemists, particularly by Boyle, Becher, and Stahl, to be capable of conversion into metallic substances; though they had vainly sought for modes of effecting this important desideratum. The celebrated Bergmann had made this *inference* with respect to *barytes.* This earth is poisonous, and extremely heavy. He, therefore, thought that it might be a metallic oxide; and Lavoisier, with his usual acuteness, extended the generalisation to lime, magnesia, and other bodies of the same class.

" When I had discovered, in so unexpected a manner, that potash and soda are *metallic oxides,* all the former analogies became strengthened to a degree, that the question of the nature of the earths was of easy solution: but, though so much more like

metallic oxides than the fixed alkalies, yet I found much more difficulty in effecting their decomposition."

Such is the brief narrative of these important discoveries; in the making of which chance was as little as possible concerned, and reason as much as possible. It is true, that the results were not exactly in accordance with expectation: in their extraordinary nature they greatly surpassed expectation; as much so, as the new regions discovered by Columbus did the old ones he was in quest of.

Some writers have detracted from the merit of these discoveries, by referring them to the means he employed, the "enormous batteries," as they have been called, which were at his disposal, in the laboratory of the Royal Institution. This is neither liberal nor just. Supposing the batteries he employed were really enormous, it was at his suggestion, and with definite objects in view, they had been constructed: but the assertion, that they were enormous, is not well founded. To effect his purpose, to bring to bear a sufficient power, he was under the necessity of uniting several different batteries; — the highest power he could then command, as he himself relates, consisting of twenty-four plates of copper and zinc of twelve inches square, 100 plates of six inches, and 150 of four inches.

The extreme delight which he felt when he first saw the metallic basis of potash, can only be conceived by those who are familiar with the operations of the laboratory, and the exciting nature of original research; who can enter into his previous views, and the analogies by which he was guided, and can comprehend the

vast importance of the discovery, in its various relations of chemical doctrine; and, perhaps not least, who can appreciate the workings of a young mind, with an avidity for knowledge and glory commensurate. I have been told by Mr. Edmund Davy, his relative and assistant, now professor of chemistry to the Dublin Society, that, when he saw the minute globules of potassium burst through the crust of potash, and take fire as they entered the atmosphere, he could not contain his joy—he actually danced about the room in ecstatic delight; and that some little time was required for him to compose himself sufficiently to continue the experiment.

As to the exact time of the discovery, it is of little importance. In his Elements of Chemical Philosophy, he says he discovered potassium in the beginning of October, and sodium a few days after; and, in the lecture already quoted, he mentions for the former the 6th of October.

Dr. Paris, in his Life of my brother, states that he commenced the inquiry on the 11th of October, and obtained his great result on the 19th. Dr. Paris draws his conclusions from the minutes of the experiments entered in the laboratory register, taking it for granted that no experiments were made but those which were entered. In regard to accuracy as to the exact time, I suppose there can be no question. It is not easy to conceive how the author could be mistaken; but it is very easy to account for Dr. Paris's mistake. My brother might have described his first experiments, as was then very much his habit, in a private note-book; or not at all, as they were of a nature not to require minute record, not being connected with weight or measure; and he

might have had recourse to the public register only when he wished to detail conclusive evidence, derived, perhaps, from a repetition of the experiments.

Never, perhaps, was a chemical investigation more intensely interesting than the one under consideration; and never, perhaps, in so short a time were so many new and surprising facts developed. The Bakerian Lecture in which they are described attests this most fully; it occupies forty-four quarto pages, and almost every page contains a new result. Notwithstanding it was a first sketch, and relating to phenomena altogether new and marvellous, it scarcely required any after correction, excepting in that part which treats of the volatile alkali; and though it was written on the spur of the occasion, before the excitement of the mind had subsided, yet it bears proofs only of the maturest judgment: the greater part of it is as remarkable for experimental accuracy as for logical precision. This is the more worthy of notice, as when he composed it he was in a feverish state, — the prelude to a severe attack of illness, which was very near proving fatal,—and his great apprehension was, that he should die before he had published his discoveries; in consequence of which dread, he applied himself the more unremittingly to the task of detailing them.

The exact cause of this illness, as well as its nature, was doubtful. In after life he expressed his persuasion that it was typhus fever; and that he had caught the contagion in one of the great prisons of the metropolis, Newgate, which he had visited, at a time that a contagious fever existed within its walls, for the purpose of suggesting means for disinfecting it. His physicians, however, adopted a dif-

ferent view of his case, as I have learned from one of them, his esteemed friend, Dr. Babington, who considered the disease as the result of over fatigue and excitement from his experimental labours and discoveries. Be this as it may, it was not only severe, but long protracted. He took to his bed about the 23d of November, and nine weeks after he was only just convalescent.

This was a golden period of his life; every circumstance, even his illness, seemed contrived to add to his popularity and fame. Had he been of the highest rank in society, greater attention could not have been paid to him, more anxious inquiries could not have been made after him. When he was at the worst, his physicians reported his state concisely in writing, for the information of the many who called to ask. In a letter now before me, written to his mother on the 7th December, the reports of the preceding day are copied, made at eight in the morning, at noon, and at nine in the evening. His physicians attended him with the greatest assiduity, and in the most friendly and disinterested manner. Two of them, Dr. Babington and Dr. Frank, were previously his friends; Dr. Baillie, who was called in when his illness was most threatening, was not behind them in kindness, disinterestedness, and attention, of which ever after my brother had a grateful remembrance.* The

* Dr. Paris in his work has made some statements connected with this event, which are deficient in accuracy, and which may deserve to be pointed out as characteristic of his manner. I shall subjoin to them Mr. Edmund Davy's remarks (with which he has favoured me in writing), who most assiduously and kindly nursed my brother, aided by Mrs. Greenwood.

At p. 185. Dr. Paris remarks, describing his illness, "His kind and amiable qualities had secured the attachment of all the officers and servants of the establishment, and they eagerly anticipated every want his

feeling which existed at this time towards him is displayed in a notice which was printed, — part of the Rev. Dr. Dibdin's Introductory Lecture on the Opening of the Institution, on the 18th of January, 1808. It commences thus: —

"Before I solicit your attention to the opening of those lectures which I shall have the honour of delivering in the course of the season, permit me to trespass upon it for a few minutes, by stating the peculiar circumstances under which this Institution is now again opened; and how it comes to pass that it has fallen to me, rather than to a more deserving lecturer, to be the first to address you.

"The managers of this Institution have requested me to impart to you that intelligence, which no one who is alive to the best feelings of human nature

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situation might require. The housekeeper, Mrs. Greenwood, watched over him with all the care and solicitude of a parent, and, with the exception of a single night, never retired to her bed for the period of eleven weeks."

On this Mr. Edmund Davy comments thus:—"I cannot speak in too high terms of Mrs. Greenwood's attentions on that occasion, but there is no truth whatever in the statement 'that, with the exception of a single night, she never retired to her bed for eleven weeks.' The fact is, that Mrs. Greenwood and myself generally watched alternate nights with your brother during his severe illness."

In the same page Dr. Paris states, that "youthful reminiscences and circumstances connected with his family and friends were the only objects which at this period occupied his thoughts, and afforded him any pleasure. No Swiss peasant ever sighed more deeply for his native mountain than did Davy for the scenes of his early years." On which Mr. E. Davy remarks, "Now these statements, though not material, were not founded in fact. He very seldom spoke of his friends, more rarely of Cornwall; nor did he once, so far as I heard, express any wish either to be among his friends in Cornwall, or to have any of them in town. He spoke very little during his severe illness, and that little had reference, in general, either to his own wants, or to the circumstances of his medical or other attendants."

can hear without the mixed emotions of sorrow and delight.

"Mr. Davy, whose frequent and powerful addresses from this place, supported by his ingenious experiments, have been so long and so well known to you, has for these last five weeks been struggling between life and death. The effects of those experiments recently made in illustration of his late splendid discovery, added to consequent bodily weakness, brought on a fever so violent as to threaten the extinction of life. Over him it might emphatically be said, in the language of our immortal Milton, that

'————— Death his dart
Shook, but delayed to strike.'

"If it had pleased Providence to deprive the world of all *further* benefit from his original talents and intense application, there has certainly been sufficient *already* effected by him to entitle him to be classed among the brightest scientific luminaries of his country: that this may not appear to be unfounded eulogium, I shall proceed, at the particular request of the managers, to give you an outline of the splendid discoveries just alluded to; and I do it with the greater pleasure, as that outline has been drawn in a very masterly manner by a gentleman, of all others, perhaps, the best qualified to do it effectually."

An outline is then accordingly given, and, in continuation, it is added,—

"These may justly be placed amongst the most brilliant and valuable discoveries which have ever been made in chemistry, for a great chasm in the chemical system has been filled up; a blaze of light

has been diffused over that part which before was utterly dark; and new views have been opened, so numerous and interesting, that the more any man who is versed in chemistry reflects on them, the more he finds to admire, and to heighten his expectation of future important results.

"Mr. Davy's name, in consequence of these discoveries, will be always recorded in the annals of science amongst those of the most illustrious philosophers of his time. His country with reason will be proud of him, and it is no small honour to the Royal Institution that these great discoveries have been made within its walls; in that laboratory, and by those instruments, which, from the zeal of promoting useful knowledge, have, with so much propriety, been placed at the disposal and for the use of its most excellent professor of chemistry."

Dr. Dibdin continues:—

"This recital will be sufficient to convince those who hear it of the celebrity which the author of such a discovery has a right to attach to himself; and yet no one, I am confident, hás less inclination to challenge it. To us, and to every enlightened Englishman, it will be matter of just congratulation, that the country which has produced the two Bacons, and Boyle, has in these days shown itself worthy of its former renown by the labours of Cavendish and Davy.

"The illness of the latter, severe as it has been, is now, however, beginning to abate; and we may reasonably hope, from present appearances at least, that the period of convalescence is not very remote."

During his convalescence, which was rather long protracted, for he was not able to resume his duties

as professor till the 12th of March (when he gave his first lecture on electro-chemical science); his mind recovered its energies much sooner than the body; proofs of which occur in a note-book kept at this time. It commences "January 24th, in convalescence after a confinement of nine weeks by dangerous fever, with bilious attacks;" with "Hints relating to the new discoveries and experiments made by H. D.;" which are followed by his opinions "concerning the elements of bodies."

During his convalescence he also amused himself with finishing a poem which he had commenced some years before, and which he now had printed. The following is a copy of it, with the heading which he then gave it:—

"WRITTEN AFTER RECOVERY FROM A DANGEROUS ILLNESS.

"Lo! o'er the earth the kindling spirits pour
The flames of life that bounteous Nature gives;
The limpid dew becomes the rosy flower,
The insensate dust awakes, and moves, and lives.

"All speaks of change: the renovated forms
Of long-forgotten things arise again;
The light of suns, the breath of angry storms,
The everlasting motions of the main.

"These are but engines of the Eternal will,
The One Intelligence, whose potent sway
Has ever acted, and is acting still,
Whilst stars, and worlds, and systems all obey.

"Without whose power, the whole of mortal things
Were dull, inert, an unharmonious band,
Silent as are the harp's untuned strings
Without the touches of the poet's hand.

"A sacred spark created by His breath,
The immortal mind of man His image bears;
A spirit living 'midst the forms of death,
Oppress'd but not subdued by mortal cares!

"A germ, preparing in the winter's frost
To rise, and bud, and blossom in the spring;
An unfledged eagle by the tempest toss'd,
Unconscious of his future strength of wing.

"The child of trial, to mortality
And all its changeful influences given;
On the green earth decreed to move and die,
And yet by such a fate prepared for heaven.

"Soon as it breathes, to feel the mother's form
Of orbed beauty through its organs thrill,
To press the limbs of life with rapture warm,
And drink instinctive of a living rill.

"To view the skies with morning radiance bright,
Majestic mingling with the ocean blue,
Or bounded by green hills, or mountains white,
Or peopled plains of rich and varied hue.

"The nobler charms astonish'd to behold,
Of living loveliness,—to see it move,
Cast in expression's rich and varied mould,
Awakening sympathy, compelling love.

"The heavenly balm of mutual hope to taste,
Soother of life, affection's bliss to share;
Sweet as the stream amidst the desert waste,
As the first blush of arctic daylight fair.

"To mingle with its kindred, to descry
The path of power; in public life to shine;
To gain the voice of popularity,
The idol of to-day, the man divine.

"To govern others by an influence strong,
As that high law which moves the murmuring main,
Raising and carrying all its waves along,
Beneath the full-orbed moon's meridian reign.

"To scan how transient is the breath of praise,
A winter's zephyr trembling on the snow,
Chill'd as it moves; or, as the northern rays,
First fading in the centre, whence they flow.

"To live in forests mingled with the whole
Of natural forms, whose generations rise,
In lovely change, in happy order roll,
On land, in ocean, in the glittering skies.

"Their harmony to trace, the Eternal cause
To know in love, in reverence to adore;
To bend beneath the inevitable laws,
Sinking in death, its human strength no more!

"Then, as awakening from a dream of pain,
With joy its mortal feelings to resign;
Yet all its living essence to retain,
The undying energy of strength divine!

"To quit the burdens of its earthly days,
To give to Nature all her borrow'd powers,—
Etherial fire to feed the solar rays,
Etherial dew to glad the earth with showers."

Fortunately, his constitution received no permanent injury from the disease he had escaped; and, in consequence, when his strength was restored, he was able to resume, with all his habitual ardour, the train of inquiry which had been so suddenly interrupted.

The prospects which now opened to him in chemical science were no less brilliant than extensive. It was difficult for the imagination to set limits to the decomposing influence of Voltaic electricity; it seemed only necessary to increase the size of the battery to increase its effect; and it was not too sanguine to suppose that no compound body would be able to resist its agency, and that, ere long, by its application, all the elements of bodies would be brought to light, and the principles of chemical science be established in an immutable manner. In the opening lecture of the first course which he gave after his recovery, on electro-chemical science, contrasting the past with the future, alluding to this power, he observes, "In this it will be seen that Volta has presented to us a key which promises to lay open some of the most mysterious recesses of nature. Till this discovery, our means were limited; the field of pneumatic research had been exhausted, and little remained for the experimentalist except minute and laborious processes. There is now before us a boundless prospect of novelty in science; a country unexplored, but

noble and fertile in aspect; a land of promise in philosophy."

With these sanguine expectations he again took the field, and, through the enlightened liberality of the managers of the Royal Institution and its principal members, he was amply supplied with all necessary apparatus to accomplish his objects. During his convalescence a voltaic battery of 600 double plates of four inches square was provided, a combination at least four times as powerful as any that had been before constructed. This was placed at his disposal; and, as he remarks in the lecture last quoted, it was provided, "not so much for the purpose of exhibiting what was already known, what might be accomplished by more simple means, as for the end of new research, and with the hope of new discovery:" and not long after, when it appeared advantageous to have a battery still more powerful, through the munificence of a few individuals, one of 2000 plates was constructed without delay, for the service of science (vide p. 204.) Nor were the means of research even limited to this powerful instrument; another presented itself in the metallic bases of the fixed alkalies, which promised to be hardly less efficient; and, happily, a chemical process was soon discovered, by MM. Gay Lussac and Thenard, for obtaining these substances in large quantities, so as to render them perfectly available.

Of the novel and important objects of inquiry, and of the zeal with which he followed them, some idea may be formed from the papers which he contributed to the Royal Society, from 1808 to 1814, and which were published in the Philosophical Transactions. The following is a list of them: —

"Electro-chemical Researches on the Decomposi-

tion of the Earths; with Observations on the Metals obtained from the Alkaline Earths, and on the Amalgam procured from Ammonia."— Read June 30th, 1808.

"An Account of some new Analytical Researches on the Nature of certain Bodies, particularly the Alkalies, Phosphorus, Sulphur, Carbonaceous Matter, and the Acids hitherto undecompounded; with some general Observations on Chemical Theory."—December 15th, 1808.

"New Analytical Remarks on the Nature of certain Bodies; being an Appendix to the Bakerian Lecture for 1808."—February, 1809.

"The Bakerian Lecture for 1809; on some new Electro-chemical Researches on various Objects, particularly the Metallic Bodies, from the Alkalies and Earths, and on some Combinations of Hydrogen."—November 16th, 1809.

"Researches on the Oxymuriatic Acid, its Nature and Combinations, and on the Elements of Muriatic Acid; with some Experiments on Sulphur and Phosphorus."—July 12th, 1810.

"The Bakerian Lecture for 1810, on some of the Combinations of Oxymuriatic Gas and Oxygen, and on the Chemical Relations of those Principles to Inflammable Bodies."—November 15th, 1810.

"On a Combination of Oxymuriatic Gas and Oxygen Gas."—February 21st, 1811.

"On some Combinations of Phosphorus and Sulphur, and on some other Subjects of Chemical Inquiry."—June 18th, 1812.

"On a new Detonating Compound."—Nov. 5. 1812.

"Some further Observations on a new Detonating Substance."—July 1st, 1813.

"Some Experiments and Observations on the Substances produced in different Chemical Processes on Fluor Spar."—July 8th, 1813.

"An Account of some new Experiments on the Fluoric Compounds; with some Observations on other Objects of Chemical Inquiry."—Feb. 13th, 1814.

I shall not attempt an analysis of these papers; I shall give merely a sketch of the most important facts and discoveries which they contain, referring the chemical reader to the original for full satisfaction. After the extraction of metallic bases from the fixed alkalies, analogies of the strongest kind indicated that the alkaline earths are similarly constituted, and he succeeded in proving this in a satisfactory manner. But, owing to various circumstances of peculiar properties, he was not able, in his first attempts, to obtain the metals of these earths in a tolerably pure and insulated state, for the purpose of examination. On his return to the laboratory after his illness, this was one of his first undertakings. He accomplished it to a certain extent, by uniting a process of MM. Berzelius and Pontin, who were then engaged in the same inquiry, with one of his own. By negatively electrifying the earths, slightly moistened and mixed with red oxide of mercury, in contact with a globule of mercury, he obtained amalgams of their metallic bases; and by distillation, with peculiar precautions, he expelled the greater part of the mercury. Even now, in consequence of the very minute quantities of the bases which he procured, and their very powerful attraction for oxygen, he was only able to ascertain a few of their properties in a hasty manner. They were of silvery lustre, solid at ordinary temperatures,

fixed at a red heat, and heavier than water. At a high temperature they abstracted oxygen from the glass, and at ordinary temperatures from the atmosphere and water; the latter of which, in consequence, they rapidly decomposed.

The names he proposed for them, and by which they have since been called, were, barium, strontium, calcium, and magnium, which he afterwards altered to magnesium.

The same analogies were nearly as strong applied to the proper earths; and he attempted their decomposition in a similar manner, but not with the same success. By the action of potassium, proof was obtained that they consist of bases united to oxygen; but whether these bases were inflammable substances merely, or metallic inflammable substances, was yet a problem, which has since been solved by the labours of Wöhler, Bussy, and Berzelius. Analogy was in favour of the latter inference, as was also the circumstance that the bases of these earths are capable of entering into union with iron; and this has been confirmed by the inquiries just mentioned, as regards the majority of them, all but the basis of silica, which still remains doubtful.

The application of these facts to geology was full of promise; and he indulged in the hope that they might serve to explain not only some of the most mysterious phenomena of nature, as earthquakes and volcanoes, and the combustion of meteoric stones and falling stars, but might ultimately lead to a general hypothesis of the formation of the crust of the earth. His ideas on the subject occur in a lecture of 1811; and I shall insert them here, as they may prove interesting to many readers, though he himself

afterwards relinquished them, in great measure, because, on examination, he did not find them tally with the actual phenomena of volcanic eruption.

" It appears, from the experiments of Mr. Cavendish, and the observations of Dr. Maskelyne, that the specific gravity of the whole earth is at least twice as great as that of the known surface. This alone might lead one to suspect that it contains metallic matter. The specific gravity is above that of the earths, and below that of the common metals, about the mean which would be produced by alloys of the metals of the earths. The eruptions of volcanoes are proved, by numerous facts, to be connected with the flowing in of water through some subterraneous cavities. And the results of volcanic fires, — the oxides of the new metals of the earths are in a state of fusion, — and all the effects are such as may be easily conceived, if we suppose them to be the consequence of the action of moisture and air upon metallic bodies, capable of being converted into earths by oxidation. Upon no other principle is it easy to account for the cessation and renovation of volcanic fires, for the enormous quantity of stony matter that they pour forth, or for the intense inflammation where there is no indication of the presence of common combustible materials, or for the usual results of combustion.

" There is in this mass of dry clay a little potassium and strontium. As long as it is dry it undergoes no change; but let it be acted on by moisture, the clay is rent in pieces, and active combustion occurs.

" This minute effect can give only a feeble idea of what might be produced by operations on a great scale in nature, in which the waters of the sea or of

lakes acted upon immense masses of the metals of the earths. In such cases the effects of the explosion might be well conceived to be felt throughout a whole continent, and the lava poured forth might cover miles of country; islands might be raised, and hills and mountains elevated.

"The influence of air and water upon our existing land is continually tending to degrade and decompose it; and our rivers are constantly carrying the divided matter of soils into the sea. For this principle of decay there must be in nature some corresponding principle of renovation; and, if we suppose the interior of the globe to be chiefly constituted by the metals of the earths, this principle will be obvious. As the surface above is destroyed, the interior must become exposed; and, from the action of water and air, new soils and new earthy substances must result, in the place of those which have been degraded and carried off; and, in the general economy of nature, electrical currents, probably the same as those exhibited in the Aurora Borealis and Australis, may be the means of disuniting inflammable matters from oxygen, and separating metals from their combinations, so as to preserve a constant and uniform relation between the solid, the fluid, and the aeriform parts of the globe."

After the decomposition of the fixed alkalies, ammonia, or the volatile alkali, became an interesting subject of inquiry. The first conjecture my brother formed, reasoning from analogy, was, that it might contain oxygen in combination with hydrogen and azote. His earliest experiments seemed favourable to the idea; but there was a fallacy in them, and it was not confirmed on their repetition.

Other conjectures respecting the intimate nature of the volatile alkali and its apparent elements speedily followed, in consequence of two very remarkable experiments, — one made by MM. Berzelius and Pontin; and the other by MM. Gay Lussac and Thenard, who, like the Swedish chemists, had entered upon the inquiries in which my brother was engaged, relative to the new objects of research, at the stage where he had been interrupted, and, with great zeal, activity, and talent, worked the rich vein which he had opened.

MM. Berzelius and Pontin, by negatively electrifying mercury in contact with ammonia, obtained an amalgam, which, in water or the atmosphere, was resolved into mercury, ammonia, and hydrogen.

The French chemists, by heating potassium in ammoniacal gas, found there was a disengagement of hydrogen, a disappearance of ammonia, and the formation of a grey compound possessed of peculiar properties. These experiments, as soon as known to my brother, received his most careful attention; and were subjected to fresh, and very minute and laborious investigation. The formation of an amalgam from ammonia seemed to imply the metallisation of its elements. The disengagement of hydrogen in the experiments of MM. Gay Lussac and Thenard, in their opinion, indicated the decomposition of potassium, and that this metal consisted of potash and hydrogen. These were problems of the weightiest kind; and it was impossible to say, in regard to doctrine, to what they might lead.

The results of his researches on the amalgam from ammonia were all of a negative and inconclusive kind. It could not be obtained without the pre-

sence of moisture; its decomposition began as soon as it was separated from the influence by which it was formed, nor could it be freed from moisture before its decomposition was complete. These circumstances interfered with any positive conclusion respecting the nature of the matter with which the mercury had combined constituting its amalgam. The more he scrutinised this extraordinary compound, the more mysterious it appeared; it proved a complete chemical Proteus, — a mystery throughout; and, were it possible for human ability to invent a thing to perplex the understanding, and unsettle systems, it would be difficult to imagine a more successful effort. The perplexing and deeply interesting nature of the problem involved in this amalgam, in relation to chemical doctrine, is strikingly indicated by the following queries, which were offered in relation to it; the first, by my brother; the second, by Mr. Cavendish; and the third, by M. Berzelius: —

"Are hydrogen and nitrogen, both metals in the aeriform state at the usual temperatures of the atmosphere, bodies of the same character as zinc and quicksilver would be at the heat of ignition?"

"Or are these gases in their common form, oxides which become metallised by deoxidation?"

"Or are they simple bodies, not metallic in their own nature, but capable of composing a metal in their deoxygenated, and an alkali in their oxygenated state?"

These were refined speculations, flowing from minds prepared to reason on the facts, and seeing the great importance of their bearings. Twenty-four years have now elapsed, and the problem is still unsolved. The last conjecture that I have read of

respecting it is, that the amalgam is merely a froth of mercury; a most crude and unphilosophical notion.*

The experiment of MM. Gay Lussac and Thenard, on the action of potassium on ammonia, was, in its results, hardly less mysterious and perplexing than the preceding. From the nature of the materials employed, it was an experiment of extreme difficulty, perhaps the most difficult ever recorded in the annals of chemical research. The metal had the most powerful attraction for oxygen; potash as powerful an attraction for moisture. These were two circumstances interfering with accuracy of results, and there were others besides; some connected with the nature of the compound formed by the action of potassium on ammonia, and some with the composition of ammonia, which had the same effect of perplexing the inferences. The labour my brother expended on this experiment was extreme; he repeated it a vast number of times, in a variety of forms, and with every precaution that his ingenuity could invent. The results he obtained were of a mixed kind. They were not so conclusive as he could have wished, in relation to the nature of azote and hydrogen; but they were amply so in regard to potassium. Nothing could be inferred, with any certainty, from them, respecting the intimate nature of either of these gases. Their nature remained, as they continue at present, unsolved problems, fit subjects for speculation and experimental research.

Concerning potassium, however, he arrived at satisfactory proof that the experiment did not, in any way, warrant the conclusion of the French chemists

* Dr. Paris, p. 193.

that it is a compound of potash and hydrogen; he showed that no more hydrogen was produced in it than might have come from the ammonia; that, when the compound formed was decomposed by heat, unless moisture was present, there was a deficiency of hydrogen in the products nearly equal to the quantity first produced; and that the more carefully the decomposition was effected, so much the more conformable were the results to the idea that neither potassium, nor azote, nor hydrogen, had been converted in the operation into any simpler form of matter; in brief, that ammonia merely had been decomposed, and a compound formed of potassium and the elements of ammonia, the proportions of which were variable according to the degree of temperature employed, and the qualities of which compound also varied in a corresponding manner.*

Even on MM. Gay Lussac and Thenard's own data, before he had repeated their experiment, he had no hesitation and no difficulty in rejecting their conclusion, and in showing it to be illogical. He had maturely considered the subject previously; in his first inquiries into the nature of the bases of the alkalies, the idea had occurred to him, that they might have been formed in the experiment, under the galvanic influence, by the union of hydrogen with the alkalies. If so, it necessarily followed that, on their combustion, when a large quantity of oxygen was condensed, the revived alkalies would be moist from the water

* What is stated in the text is in accordance with his latest experiments on the action of potassium on ammonia. In a manuscript note to his paper of the 15th of December, 1808, he says, "From some experiments made with great care in 1815, in tubes of platina, I find that almost all the potassium can be recovered, and then very little nitrogen is lost."

formed; but the contrary occurred,— the potash and soda, formed by burning potassium and sodium, were unusually dry. This simple experiment was conclusive to his mind against the new metals being hydruretted alkalies.

Another view he pointed out might be taken of them, which was the phlogistic, the same as Mr. Cavendish had before taken of all the metals; viz., that they are compounds of hydrogen and unknown bases.

This view was refined and defensible; it could not have been refuted; it was admirably adapted to explain very many phenomena; very many facts were in its favour; and, for a considerable time, he inclined to it, as both his published papers and unpublished notes indicate. The following are some of these, which, as already mentioned, were begun during his convalescence. As a literary curiosity, and record of speculative opinion, I shall transcribe them verbatim: —

" *My Opinions concerning the Elements of Bodies.*

" If the electrical energies of bodies be examined, oxygen, and all bodies that contain a considerable proportion of oxygen, appear to be *negative;* hydrogen, the metals, and all combustible bodies, *positive.*

" Amongst the oxygenated bodies, all that are solid are non-conductors; all the fluid ones are imperfect conductors. Sulphur, phosphorus, and diamond — sulphur and phosphorus contain hydrogen, most likely also the diamond; and the compounds of hydrogen are generally non-conductors.

" A new phlogistic theory might be established,

which would explain all the phenomena, as well as the antiphlogistic.

"Thus, as we know oxygen is a principle possessing negative electricity, and hydrogen positive; and as all bodies assembling at the positive contain oxygen, so may all bodies assembling at the negative contain hydrogen; and the electricity of oxygen and hydrogen neutralize each other when they are to each other as eighty-five to fifteen in weight.

"Every body considered as a simple combustible will, on this hypothesis, consist of hydrogen, in different quantities, united to different bases; and these bases must be negative, but not sufficiently to neutralize the energy of the hydrogen.

"Now, when a metal or an inflammable becomes increased in weight by the action of air, it may be supposed to be owing to a triple combination of oxygen, hydrogen, and the basis, in which the neutralization of energy is more or less perfect according to the degree of oxygenation.

"When an inflammable substance is revived by the action of heat or hydrogen, the hydrogen combines, and oxygen (as in the case of mercury acted on by heat) or water is expelled (as in the case of the revival of metallic oxides, in Priestley's experiments by inflammable air).

"When a metallic oxide is revived by charcoal, &c. the hydrogen of the charcoal displaces the water of the metal.

"When oxide of mercury is revived by charcoal, the charcoal retains its hydrogen, and the oxygen from the oxide combines with the compound to form carbonic acid; so that acids, oxides, and alkalies are all combinations of water with a metallic basis."

"THIRD THEORY.

"*Extension and Improvement of the last.*

"May not water, combined with two different imponderable principles, one acting the negative, the other the positive part, constitute oxygen and hydrogen? and may not these two etherial principles be what some excellent electricians have called vitreous and resinous electricity? and may they not form fire by their attraction or neutral approximation? Then, whenever they were discharged, water would appear; and if they were discharged when one portion of water was in chemical union with other matter, there is no reason why the other portion, free from elastic matter, should not fix itself, which would account for oxydation.

"There are abundant analogies in favour of hydrogen changing the physical properties of the inflammable solids, and rendering them non-conductors.

"A minute portion in weight of the basis of potash, *i. e.* $\frac{1}{50}$, solidifies mercury, and the heat produced by their union is intense. There may not exist $\frac{1}{1000}$ part of hydrogen in diamond, and yet it may be adequate to explanations. Charcoal seems to be non-conducting when it does not contain $\frac{1}{100,000}$ part of its weight of hydrogen.

"If we suppose water *simple*; then,
"Oxygen will be water —
"Hydrogen, water +
"The metals,...Unknown bases, water +

$$\left.\begin{array}{l}\text{" Charcoal,}\\ \text{" Sulphur,}\\ \text{" Phosphorus,}\\ \text{" Nitrogen,}\end{array}\right\}\text{Unknown bases, water +}$$

"Acids, oxides, alkalies, and earths, } Unknown bases, water—.

"In this theory all the elements, except water, are supposed x and y."

But, though defensible, these views were merely hypothetical, fitted as he used them, for hints in research, as they might be true; but, till proved to be so, and reduced to matter of fact, unfit to become the doctrines of science.

The history of opinion relative to the metals of the fixed alkalies is a striking instance of the shackled state of the mind, how strongly attached it is to old notions, how firmly fixed in its prejudices.

When the discovery of these metals was first announced, and their extraordinary properties described, especially their extreme lightness and inflammability, opposition was immediately made; and one hypothesis was advanced after another, to explain circumstances which, because never witnessed before associated with metallic bodies, were considered as anomalous: by some, potassium and sodium were called hydrurets; by others, metalloids. These fancies have now passed away, and are almost forgotten. They were most easily refuted. My brother having shown that potassium and sodium possess the most characteristic qualities of metals, as peculiar lustre, power of conducting electricity, opacity, combustibility, power of forming bodies soluble in acids; having shown that, between potassium and platinum, the one lighter than ether, the other the heaviest body known; the one as fusible as wax, and inflammable on ice, and the other resisting fusion and combustion in the strongest heats of the furnace; having shown that, between them, the other metals form a complete chain of union by gradation of properties —

the conclusion was irresistible, that they all belong to one class; and that it would be just as philosophical to reject arsenic from the class of metals on account of its brittleness, or mercury on account of its fluidity, as potassium and sodium on account of their lightness.

Fortunately, in science, as in politics, opposition is wholesome, and, properly conducted, leads to truth and improvement — *Veritas est magna et prevalebit.* The discussion of the nature of the alkaline metals led to the discovery of several interesting particulars, and enriched chemistry with some important facts, especially regarding the combinations of these metals with oxygen, and their oxides with water: in regard to the latter, proving that potash and soda, so long considered simple bodies, are actually double compounds and hydrates; and that the pure oxides had never been witnessed till they were formed directly by the combustion of the metals.

After the decomposition of the fixed alkalies, doubt naturally spread through every department of chemistry; a salutary doubt, prompting further inquiry and scrutiny, by means of the new powers of analysis. Sulphur, phosphorus, and carbon were, according to the antiphlogistic views, considered simple substances; but they might be compounds. For the purpose of investigating their nature, my brother subjected them to many experiments. The results of his first experiments on phosphorus and sulphur were favourable to the conclusion that these bodies are compounded, and that they both contain oxygen and hydrogen. His latest researches, however, induced him to suppose that the indications which he had obtained of the presence of the oxygen and hydrogen were occasioned by the sulphur and phosphorus operated

upon not being pure, having been contaminated with oxide, or water, or both.

In the inquiry relative to the nature of sulphur, one fact strongly impressed him, and it deserves to be kept in recollection, and made the subject of further research. I allude to the large quantity of sulphuretted and telluretted hydrogen which is generated when sulphur and an alloy of potassium and tellurium are heated together. He considered this result as indicating either the decomposition of sulphur, or of potassium, or of tellurium, or of all three bodies, and one of the strongest facts in favour of a phlogistic hypothesis.

From his experiments on the diamond and charcoal he was disposed to infer that a minute portion of oxygen is essential to the former, and that hydrogen is essential to the latter,—inferences not confirmed by later researches, which he engaged in at Florence and Rome, and which will be noticed in the sequel.

Analogy had always indicated the compound nature of certain acids, which, up to that time, had resisted all attempts to effect their decomposition. These acids were the boracic, muriatic, and fluoric. In a former part of this work, it has been mentioned how he tried his youthful strength against them, and failed. He now returned to the enterprise, and, with the more powerful agents which he could bring against them, succeeded perfectly.

The obvious analogy was that founded on the dogma of Lavoisier, of oxygen being the acidifying principle; and that as acids, the composition of which was known, consist of bases and oxygen, so those of unknown composition likewise must.

With this guide he commenced his researches, and

he soon had the satisfaction of proving its correctness in relation to boracic acid: acted on by the voltaic battery, it underwent decomposition; a brown matter collected at the negative pole, which proved to be its inflammable base; the same effect on it was produced by the action of potassium, from the more powerful affinity of the latter for oxygen; and the result of analysis was confirmed by synthesis. By heating boron (as the inflammable base was called) in oxygen, it burnt, and was reconverted into boracic acid.

Here we have an instance of the beneficial effects of analogy aiding the discovery of truth, and the extension of science. In the inquiry which he instituted into the nature of the muriatic acid, we have a contrary instance how a plausible analogy may be false, and lead to error, and tend to shackle science, and prevent the advancement of knowledge; and how (as he himself remarks in an early lecture on chlorine) "in the physical sciences there are much greater obstacles in overcoming old errors than in discovering new truths; the mind, in the first case, being fettered, in the last perfectly free in its progress." In accordance with what Bacon says, that "if false facts in nature be once on foot, what through neglect of examination, the countenance of antiquity, and the use made of them in discourse, they are scarce ever retracted." * He entered upon the inquiry, not doubting the correctness of the analogy; not doubting that the muriatic acid gas, up to that time, had not been decomposed; that it probably contained oxygen as an acidifying principle united to some base; and that oxymuriatic acid gas (as chlorine was then

* De Augmentis Scientiarum, p. 6.

called) is a compound of muriatic acid gas and oxygen loosely united.

His object was to obtain the supposed base of muriatic acid, to separate the oxygen it was supposed to contain, and insulate the substance of which he was in quest: all his attempts were ineffectual. Most perplexing and anomalous results occurred. To account for them on the old hypothesis, it was necessary to suppose that water is essential to muriatic acid gas; and that muriatic acid without water or oxygen, in brief uncombined, had never been witnessed.

Arrived at this stage of the inquiry, he reviewed the subject in its details; vigorously threw aside all preconceived notions, and came to the conclusion that oxymuriatic acid gas, according to the opinion of Scheele, who discovered it, is a simple substance; that it is analogous to oxygen, and forms muriatic acid gas by union with hydrogen. I know no train of chemical inquiry more interesting and instructive than this, and better deserving of being carefully studied. It is a model, as it appears to me, of research and reasoning, and a beautiful instance of the gradual developement of an important truth, which was the beginning of a very beneficial reform in doctrine. This, indeed, was a remarkable time in the history of chemistry; a general revolution was on the eve of taking place; and my brother performed a part in relation to the dogmatism and false doctrine of the French school, very similar to that which the founder of this school, the illustrious Lavoisier, performed in regard to the Stahlian hypothesis,—a part, it is easy to conceive, Lavoisier himself would have acted, had he been guided by the same lights;—admitting nothing to be proved which was not proved; calling what was

doubtful, doubtful; considering the bodies which were not decomposed as simple substances; rejecting unknown or imaginary principles; and, in brief, following as strictly as possible that method of philosophising which is known by the name of inductive, to which modern science, without doubt, owes much of its excellence, and without which science would soon become little better than a romance,—a motley and vain assemblage of opinions, fancies, and facts. I shall now place before the reader a brief sketch of this inquiry, as it forms one of the most important parts of my brother's scientific labours, and, in relation to doctrine, the most important and original.

He began the investigation by attempting the decomposition of muriatic acid gas by means of potassium. The action of the metal on the acid was violent, even to inflammation. Hydrogen gas was produced, about the same quantity as if the potassium had acted on water, and a white salt was formed; and the results were precisely the same, however carefully the muriatic acid gas was dried. In this experiment the hydrogen was supposed to have come from water adhering to or belonging to the muriatic acid gas.

The next step was to endeavour to obtain muriatic acid free from water, so as to be in a more favourable state to be acted on. The decomposition of dry muriates was attempted, by intensely heating them with dry phosphoric and boracic acid, but without effect; and equally without effect with silica; though, when aided by moisture, muriatic acid gas was disengaged in the greatest abundance.

These experiments failing, he directed his attention to oxymuriatic acid gas, and endeavoured to obtain

dry muriatic acid by means of sulphur and phosphorus; supposing that these inflammable substances, with a strong attraction for oxygen, would combine with it, and that the acid would be detached. But the result did not correspond to this idea: no separation occurred, but new combinations; sulphur formed, with oxymuriatic acid gas, a liquid volatile compound, and phosphorus two compounds; one liquid, and one solid; both volatile.

The next trial to be mentioned was a most important one. Having prepared a piece of charcoal by intensely igniting it in an exhausted globe, by means of the voltaic battery, and having dried oxymuriatic acid gas carefully by means of anhydrous muriate of lime, he passed the gas into the globe, and repeated the ignition of the charcoal. No change occurred: the charcoal gave no signs of combustion; the chlorine remained perfectly unaltered.

It was now he began to doubt the very existence of oxygen in oxymuriatic acid gas. If it contained oxygen, why was it not separated by a substance most strongly attracting it, aided by an intense heat, and without any interfering cause to prevent or disguise the result?

He did not rest here, but instituted other experiments on the same plan. In Libavius's liquor, or the volatile muriate of tin, dry muriatic acid was supposed to be united with oxide of tin, in the same manner as it was supposed to be united with dry phosphoric acid in the solid compounds already mentioned, formed by the action of phosphorus on oxymuratic acid gas. If this view were true, it was probable that ammonia would effect the decomposition of these bodies; that it would unite with the mu-

riatic acid, and that, by the application of heat, the muriate of ammonia would sublime, and oxide of tin and phosphoric acid be obtained. Such were not the results; both were perfectly new, and unexpected; the ammoniacal gas united with the liquor of Libavius, and formed a solid volatile compound; it united also directly with the phosphoric sublimate, and formed a solid fixed compound, having a great deal of the character of an elementary substance, and which, had it been found ready formed in nature, might have passed for a new earth or oxide.

It had been previously asserted that, when ammoniacal gas and oxymuriatic acid gas are mixed together, water is formed by the mutual decomposition of the acid gas and of part of the alkaline. This was in accordance with the idea of loosely combined oxygen in oxymuratic acid gas. He repeated the experiment, but could procure no water; the products were dry muriate of ammonia, and some free azote.

The last experiment in the chain of evidence related to muriatic acid gas. Mr. Cruikshank had shown that when about equal parts of hydrogen and oxymuriatic acid gas are mixed, they produce a compound almost entirelycondensible by water. MM. Gay Lussac and Thenard, who had been ably investigating the nature of muriatic acid, at the same time that my brother was so employed, and who had obtained many results similar to his, and some of much value peculiar to themselves, stated that this matter was muriatic acid gas, and that no water is deposited in the operation. This experiment he very carefully repeated, and the results he obtained confirmed those of the French chemists; the more care was

taken in drying the gases, the mercury, and the vessels, so much the less condensation was observed; admitting of the conclusion, that were foreign moisture excluded entirely, one volume of hydrogen and one of chlorine, on union, would form exactly two of muriatic acid gas.

Messrs. Gay Lussac and Thenard, by their researches, had satisfied themselves that in all the decompositions in which oxygen was expelled, in which oxymuriatic acid gas was concerned, water or some other body was present known to contain oxygen. They stated, therefore, that oxymuriatic acid gas might be considered a simple substance; that the phenomena relating to it admitted of being explained on that hypothesis; but at the same time they gave the preference to the view of it in accordance with the doctrines then prevalent, that it is a compound.

My brother also having satisfied himself of the truth of this, and further, that water cannot be obtained from muriatic acid directly, only by means of bodies known to contain oxygen, he considered the existence of water in it, and of oxygen in oxymuriatic gas, as hypothetical assumptions; and preferred the original view of Scheele as an expression of facts—viz. that oxymuriatic acid gas is an undecompounded or simple substance, and muriatic acid gas a compound of it and of hydrogen. Such is the train of research and argument which led to this important conclusion; it was merely a returning to the first principles of modern chemistry—those by which the phlogistic hypothesis had been overthrown, which, as modified by Mr. Cavendish, might be defended as an hypothesis, but could not be maintained as a statement of facts.

Thus is it, also, with the doctrine of oxymuriate acid gas; with as much propriety may metals be called compounds of bases which have never been obtained separate and phlogiston or hydrogen, as oxymuriatic gas called a compound of a base which has never been procured apart and oxygen. My brother did not assert that oxymuriatic gas is an element, a real indestructible principle, no more than he did that the metals are such elements: he merely held that the one, like the others, is in our arrangements to be viewed as elementary in the modern acceptation of the term, as long as it remains undecompounded, this being the only practical criterion of an elementary body.

From this point, the inquiry relative to oxymuriatic acid gas may be considered as having taken another and novel direction — a course which conducted to new researches, and brilliant and important discoveries, both in relation to the facts and doctrines of science.

As soon as he had satisfied himself of the above conclusion, that there was no evidence for the decomposition of oxymuriatic gas, that it required to be received as a simple substance, it was natural for him to inquire, to what class of bodies it belongs; that is, to what other substances its properties are most analogous. By a careful examination of its properties, he inferred that it is more analogous to oxygen than to any other substance: thus, in its electrical relations, like oxygen, it is powerfully attracted by the negative pole of the voltaic battery; in relation to heat and light, like oxygen, combustion is a frequent accompaniment of its entering into combination; like oxygen, also, though not acid in itself, it forms acid matter by union with inflammable

substances. He proposed, therefore, to class it with oxygen, as a supporter of combustion and acidifying principle ; — using the term, not in the original and strict acceptation as employed by Lavoisier, but merely as convenient expressions in connection with classification, in the same manner as the term inflammable is applied to the bodies with which they unite, and in the act of uniting with which, inflammation is produced.

This classification was productive of the best effects ; it broke down a great barrier of doctrine that had in a manner been consecrated by the genius of Lavoisier ; it did away with an exclusive principle of acidity and combustion ; it dispersed a thick mist of prejudice through which chemists had been in the habit of viewing the phenomena of science ; removed all obstacles to the natural arrangement ; and, as we shall see hereafter, led to a great extension of chemical science.

As the name, oxymuriatic gas, was totally unappropriate to the substance to which it was applied, whether considered in its composition or properties, it was necessary to discontinue it ; and my brother proposed as a substitute for it that of chlorine, a name independent of speculation, derived merely from the colour of the gas. On the same principle of avoiding a speculative nomenclature, he proposed to designate the combinations of chlorine by the names of their bases with the termination *ane ;* a proposition which, perhaps wisely, has not been followed, as it would have been very inconvenient in use, perplexing the mind like a short-hand character.

Having now given a brief sketch of these researches, I have nearly performed my task in relation to them. His views were readily adopted by the most eminent

chemists of Europe; and, with a few exceptions, in less than two years from their promulgation, they were very generally received and taught in the schools. This was no more than might have been expected in an enlightened age, considering the nature of these views, their simplicity, the facility with which they explained phenomena, the inducements they held out to further research, and the promise they afforded of further discoveries.

The only individual I need mention, who resisted with any pertinacity, and made a protracted defence of the old doctrine, was Mr. (afterwards Dr.) Murray, an ingenious lecturer on chemistry in Edinburgh, who, I believe, never gave up his early opinion, that chlorine is a compound of muriatic acid and oxygen; or rather, his modified opinion, that it is a compound of oxygen and dry muriatic acid. In support of the old doctrine, he published a series of papers in Nicholson's Journal, which my brother delegated me to answer. The controversy, as most frequently happens, was conducted with unnecessary warmth and asperity; however, it was not unproductive of good. It brought the subject strongly before the philosophical public, and was probably instrumental in deciding the question sooner than if the new doctrine had encountered no active opposition. And, what was more important, it was the means of bringing to light two gases, which, till then, had not been known: — Euchlorine, a compound of chlorine and oxygen, which was discovered by my brother, in January 1811; and Phosgen, a compound of chlorine and carbonic oxide, which I discovered the same year. Both these gases, there is reason to suppose, were present and acted in Dr. Murray's experiments, without his

knowledge of the circumstance, and gave rise to results of a deceptive character. After an interval of twenty-five years, I have much pleasure now in looking back on this happy period of my life, when the whole of my time was devoted to chemical studies and pursuits in their most interesting and alluring form; and, I can never forget the lively interest my brother took in what I was doing. When I ascertained the existence of phosgene gas, he was out of town. On his return I related to him all the particulars, and I am quite sure he felt more pleasure than if he had made the discovery himself. I shall be excused, I trust, for mentioning this little incident connected with myself, as it tends to display his warm sympathy in the success of others.

His researches relative to fluoric acid, which were commenced at the same time as those we have just been considering relative to the muriatic acid, did not make the same rapid progress, nor were the results equally successful. This arose from the nature of the subject. When he began the inquiry in 1808, the knowledge chemists possessed of fluoric acid and its combinations was imperfect and vague; his first experiments, on this account, were of little avail. When he resumed the inquiry in 1813, the difficulties just alluded to were in great measure removed; a great deal of precise information had been collected respecting the fluoric compounds. It was proved in a satisfactory manner, that there are distinct forms of acid, capable of being obtained from fluor spar; one liquid, called fluoric acid, and two aëriform; one named silicated fluoric acid gas; the other, fluoboracic acid gas, as from the former silica was procurable, and from the latter boracic acid. Now,

obstacles of a different description presented themselves, arising out of the peculiar properties of the compounds themselves. The liquid acid is of a very unmanageable nature; it is not confinable in glass; and it acts even in vapour on the skin so powerfully that it is not easy to experiment on it, without suffering from its violent acid and corrosive qualities. The gaseous compounds, it is true, are more tractable; but their compound nature tends to render the results obtained in operating on them more or less obscure; and the fluoric element which they contain, as soon as liberated, exhibits, even more strongly marked than the liquid acid, a character of intractableness, in consequence of which its precise nature, and that of the fluoric combinations, are still problematical.

My brother's researches relative to the fluoric combinations owe much of their interest to these difficulties. The perusal of them will well repay the chemical reader; in point of ingenuity and original invention, they are not inferior to those on chlorine; and it is not easy to find a more striking instance of the aid of analogy in directing experiment, and of the necessity and advantage of trying the truth of analogy by experiments.

He enters on the inquiry by pointing out three hypotheses, which may be framed in accordance with the then known facts on the nature of the fluoric combinations, and which may be enumerated, to confirm what has been said of the great difficulty and obscurity of the subject: —

"In the first, which is that generally adopted, the ilicated fluoric acid gas is supposed to be a compound of silica and a peculiar acid, itself consisting of in-

flammable matter and oxygen; fluo-boracic acid gas, a compound of boracic acid and the same acid; and pure liquid fluoric acid, as water combined with the acid.

"In the second hypothesis, the silicated fluoric acid is conceived to consist of a peculiar undecompounded principle, analogous to chlorine and oxygen, united to the basis of silica; the fluo-boracic acid of the same principle united to boron, and the pure liquid fluoric acid as this principle united to hydrogen.

"In the third hypothesis, which probably would have been formed by the disciples of the Phlogistic School of Chemistry, had they been acquainted with the facts, the liquid fluoric acid is considered as an undecompounded body, and the metals and inflammable bodies as compounds of certain unknown bases with hydrogen; silicated fluoric acid gas, on this idea, must be regarded as a compound of the fluoric acid with the basis of silicum, and fluo-boracic acid gas as a compound of the fluoric acid and the basis of boron." *

He adds, "It is not easy to devise simple experiments to ascertain which of these hypotheses is true; yet in admitting strict analogical reasoning, it is easy to show which is most conformable to the general series of chemical facts." And with this object in view his experimental research was conducted.

By the action of ammonia on liquid fluoric acid, he could obtain no proof of the existence of water in it.

By the action of potassium on the fluate of ammonia, no proof was afforded of the acid being an inflammable base united with oxygen; the results

* Phil. Trans. 1815.

obtained were the same as when potassium is made to act on muriate of ammonia.

With great difficulty, owing to the energetic powers of fluoric acid, he succeeded in submitting it to the test of the voltaic battery. And, again, the results are most favourable to the idea that it is analogous to the muriatic acid, — composed of a principle, like chlorine, in union with hydrogen. And to this view of its nature he gives the preference, considering all the phenomena of the experiments, both on the liquid acid and the silicated fluoric and fluoboracic acid gases, as most conformable to it.

Assuming the truth, then, of this analogy, it followed of necessity that it was in vain to attempt the decomposition of the fluoric acids by combustible substances; by means of which only new compounds can be obtained. Following the same process of reasoning, it appeared to him probable that the decomposition might be effected by oxygen or chlorine; that, as chlorine, under certain circumstances, expels oxygen and, under others, oxygen expels chlorine taking its place in combination, — so one or other of these principles might possibly expel the fluoric principle he was in quest of. With this happy idea, he instituted many experiments, the results of some of which were in accordance with it. Thus, when chlorine was made to act on fluates containing bases which there was reason to suppose have a greater affinity for chlorine than for the fluoric principle, there was an effervescence — a decomposition of the fluat, and a chloride was formed, and the fluoric principle was separated, — but which immediately united itself with the matter of the vessel, whether glass or metal.

He next tried to collect the substance disengaged

by chlorine, which I have called the fluoric principle, so as to obtain it separate; but in this attempt he failed: he could find no vessel capable of holding it free.

However, the proofs of the existence of such a principle, analogous to chlorine and oxygen, were so convincing to his mind, that he ventured to assign it a name, fluorine, that had been proposed by M. Ampere, who, independently of my brother, guided merely by analogy, had concluded that such a principle must exist.

In the brief history of the train of investigation which has just been given, relating to chlorine and to fluorine, it appears to me instructive to observe the pointed difference of my brother's views respecting them; how he considers the existence of the one as an established fact, and how he infers the existence of the other only as a probability; the one substance being readily obtained in an insulated state, and easily submitted to experiment in this state, and having resisted every means employed to decompose it; the other substance, on the contrary (if substance it may be called), having been examined only in combination, neither glass or metal of any kind being capable of isolating it; and, consequently, not within the reach of the senses, but a proper subject for analogical reasoning. Supposing that chlorine acted on glass like the fluoric principle, and as energetically on the metals and on water, our knowledge of it would be almost precisely similar to that which we possess of fluorine; and now, as in combination the analogy between them appears to be complete, it seems most reasonable to infer that the two substances belong to the same class of bodies. The demonstration, how-

ever, is wanting; and till the fluoric principle is obtained separate, this inference, reasonable as it is, is only conjectural. This should never be lost sight of, if a strict logic is to be maintained in relation to the doctrines of chemistry, as is most desirable.

The reader has now before him a brief sketch of the most important scientific labours of my brother, between 1808 and 1814, but not of the whole of them. I have made slight mention of his discovery of a compound of oxygen and chlorine possessing very remarkable properties. I have also to mention his discovery of two other gases; one a compound of tellurium and hydrogen, and the other of phosphorus and hydrogen: and of two solid compounds; one composed of water and phosphorus acid, or hydrophosphorus acid, which, by heat, is resolved into phosphoric acid, and the phosphuretted hydrogen just alluded to; and the other formed by the union of sulphureous acid gas, and nitrous acid gas, and aqueous vapour,— a compound which acts a very important part in the ordinary process of manufacturing sulphuric acid by the deflagration of sulphur with nitre. And even other discoveries might be mentioned in addition, which he made during this period; but the mere enumeration of them would be without interest; and the detail necessary to make them intelligible and interesting to those who are only generally acquainted with chemical science, would be here out of place.

In the next chapter, in which I shall continue his personal history, I may have occasion to revert to the subject. Sufficient, and more than enough, I trust, has been brought forward, to show how ardently he prosecuted science, and how amply he was rewarded

with success. He was excited by a noble ambition to distinguish himself; and, even when most popular, he looked beyond the popularity of the hour and day. Writing to my mother, in August 1809, he says, " At present, except when I resolve to be *idle* for health's sake, I devote every moment to labours which I hope will not be wholly ineffectual in benefiting society, and which will not be wholly inglorious for my country hereafter ; and the feeling of this is the *reward* which will continue to keep me employed."

CHAPTER VIII.

IDEA OF RESUMING THE MEDICAL PROFESSION. — LECTURES AT THE DUBLIN SOCIETY. — LETTERS TO HIS MOTHER AND BROTHER. — HIS MARRIAGE. — HIS "ELEMENTS OF CHEMICAL PHILOSOPHY." — THE ATOMIC THEORY. — HIS ESTIMATION OF MR. DALTON. — NOTICE OF THE GREAT VOLTAIC BATTERY OF THE ROYAL INSTITUTION. — SOME OTHER EXTRACTS. — HIS VIEWS ON CHEMICAL NOMENCLATURE. — CONTINUES HIS SCIENTIFIC PURSUITS. — IS WOUNDED IN THE EYE IN EXPERIMENTING ON A NEW DETONATING COMPOUND OF CHLORINE AND AZOTE. — OBTAINS PERMISSION FROM THE FRENCH GOVERNMENT TO PROCEED THROUGH FRANCE INTO ITALY.

When my brother accepted the appointment of Professor of Chemistry in the Royal Institution, he laid aside, for a time, the study of the medical profession, and devoted himself exclusively, as we have seen, to scientific research. Now that he had attained distinction as an original inquirer, and a great degree of popularity, especially in the higher circles of London society, he appears to have had it in contemplation to resume his professional studies, with the view to engage in medical practice as a physician. For this purpose he entered his name at Cambridge, and kept some terms there. He was probably induced to form this plan by a prospect of fortune, in a professional career, infinitely greater than he had any right to expect from the mere prosecution of science. From the latter he derived a competency, and little more; from the other, he might calculate on making an independence, and on acquiring means of his own for prosecuting his favourite pursuits. Moreover, I have little doubt, that with his sanguine

temperament and enlarged views, he might at this time have anticipated discoveries in medicine, not inferior to those which he had already made in chemistry; flattering himself with the hope of becoming, in a double sense, the benefactor of his fellow men. But science had too strong a hold on his affections to allow him to carry into effect this plan; and without any struggle, I believe, he gave it up: he must have been convinced, on reflection, that he could not have followed it successfully, in regard to fortune, without making an entire sacrifice of science.

During the period he continued to lecture in the Theatre of the Royal Institution his popularity was constantly increasing, and the size of his audience kept pace with it. Latterly it was scarcely less than 1000. His lectures were so attractive, that had he chosen to have retired from the Institution, like his predecessor, Dr. Garnet, and to have opened a course on his own account, he might probably have acquired a large income. But he had a greater pleasure in giving his support to an establishment which he considered useful to society, with which he associated his fame, and which, without his exertions, would have had but a short-lived existence.

In consequence of his reputation and discoveries he was twice invited to deliver courses of lectures to the Dublin Society successively, in 1810 and 1811; and I may here introduce some extracts from a copy of the minutes of the Society, for which I am indebted to Mr. E. Davy, recording the manner in which the invitation was given, and the impression which his lectures made.

"*From the Proceedings of the Dublin Society, May* 3. 1810.

"*Resolved*,—That it is the wish of the Society to communicate to the Irish public in the most extended manner (consistent with the engagements of the Society), the knowledge of a science so intimately connected with the improvement of agriculture and the arts, which it is their great object to promote; and that, with this view, it appears to them extremely desirable to obtain the fullest communication of the recent discoveries in electro-chemical science which have been made by Mr. Davy.

"*Resolved*,—That application be made to the Royal Society, requesting that they will be pleased to dispense with the engagements of Mr. Davy*, so far as to allow the Dublin Society to solicit the favour of his delivering a course of electro-chemical lectures in their new laboratory, as soon as may be convenient after the present course of chemical lectures shall have been completed by their professor, Mr. Higgins.

"*Resolved*,—That the sum of 400 guineas be appropriated out of the funds of the Society, to be presented to Mr. Davy, as a remuneration, which they propose him to accept, and as a mark of the importance they attach to the communication they solicit."

"Mr. Davy arrived in Dublin, and delivered his course of lectures to a crowded auditory. At the close of his lectures the following resolutions were passed: —

"*Nov*. 29. 1810. *Resolved*,—That the thanks of the Society be communicated to Mr. Professor Davy,

* He was at this time Secretary to the Royal Society; an appointment he obtained in 1807, and held till 1812.

for the excellent course of lectures which, at their request, he has delivered in their laboratory; and to assure him, that the views which led the Society to seek for these communications have been answered even beyond their hopes; that the manner in which he has unfolded his discoveries has not only imparted new and valuable information, but, further, appears to have given a direction of the public mind towards chemical and philosophical inquiries, which cannot fail in its consequences to produce the improvement of the sciences, arts, and manufactures in Ireland."

"*June* 13. 1811. *Resolved*,— That a letter be written to Mr. Professor Davy, requesting him to favour the Dublin Society and the Irish public with a further communication of the recent discoveries in chemical philosophy, and to deliver a course of lectures in their laboratory for that purpose, in the months November and December next; and requesting that he will also repeat to them, at the same time, the course of lectures in geological science which he has read this year to the Royal Institution; and that he will be so good as to procure for the Society copies of as many of the geological sketches referred to in that course as he may think necessary for the elucidation of the subject; and further requesting him to superintend the construction of a voltaic battery of large plates, for the use of the Society, to be transmitted to them in time for these lectures."

"*Dec.* 5. 1811. *Resolved unanimously*,—That the thanks of the Society be communicated to Mr. Davy, for the two excellent courses of lectures in chemical and geological science which, at their request, he

has delivered in their laboratory, full of valuable information; and which have not merely continued, but materially increased, the spirit of philosophical research in Ireland.

"*Resolved unanimously*, — That Mr. Davy be requested to accept the sum of seven hundred and fifty pounds, as a remuneration on the part of the Society."

At the same time, the degree of LL.D. was conferred on him by Trinity College, Dublin. A letter written to my mother, after his arrival in Ireland, in 1811, previous to the commencement of his lectures, will give a more lively idea of the estimation and regard in which he was held.

"Balina, Ireland, Oct. 24.

"MY DEAR MOTHER,

"I am safe and well, in a remote and beautiful part of Ireland, where I have been making an excursion with two of my friends.

"I shall return to Dublin in two or three days, and shall be very glad to hear from you or my sisters there. I hope you are all well and happy.

"I heard from John a few days ago; he was quite well and in good spirits.

"The laboratory in Dublin, which has been enlarged so as to hold 550 people, will not hold half the persons who desire to attend my lectures. The 550 tickets issued for the course by the Dublin Society, at two guineas each, were all disposed of the first week; and I am told now that from ten to twenty guineas are offered for a ticket.

"This is merely for your eye; it may please you to know that your son is not unpopular or useless.

Every person here, from the highest to the lowest, shows me every attention and kindness.

" I shall come to see you as soon as I can. I hear with infinite delight of your health, and I hope Heaven will continue to preserve and bless a mother who deserves so well of her children.

" I am your very affectionate son,

" H. Davy.

" My kindest love to my sisters and aunts."

When his lectures were concluded, he wrote to me to the same effect. In a letter, dated December 1st, he says, —

" I have nearly finished my business here: my lectures have been received with the highest interest, and the tone of hospitality, kindness, and respect towards me is even higher, if possible, than last year."

At this period he may justly be considered at the height of his popularity, and perhaps of his happiness. He had earned an unsullied and noble reputation; he was loved and admired by friends, who had cheered him on in his career; he had hardly passed the prime of manhood *; he was in possession of excellent health; he had open to him almost every source of ordinary recreation and enjoyment; and he had, besides, the unfailing pleasures derived from the active and successful pursuit of science. His letters written at this time, such as I have had an opportunity of consulting, strongly mark a happy contentment, as well as a very amiable and affectionate state of mind. I more particularly allude to those which he addressed to his mother and sisters, and

* In 1811 he was 33.

to myself. After spending three years with him at the Royal Institution, we parted in the autumn of 1811; he to proceed to Ireland, and I to commence my medical studies in Edinburgh. Many years older, the interest he took in me more resembled that of a father than of a brother; and it is with peculiar pleasure I now reflect on his various kindnesses; my numerous obligations (many of which were delicately concealed at the time, as I have since learnt from his correspondence with my mother); his valuable hints and generous encouragement in regard to my studies, leaving me free to follow the bias of my own mind; and his excellent advice in respect to my conduct, in which was always infused a native nobleness of sentiment, well adapted to stir up virtue in a young mind. In illustration of this, I shall give a portion of a letter which I received from him from Dublin. In relation to himself, I could have wished to have given the whole, it is so strongly expressive of his natural goodness and kindness of disposition, and of his high and delicate sense of moral rectitude, but it is too flattering in regard to myself; and even part of what I give is of this description, written by one who knew that the voice of praise is one of the strongest incentives to virtue, and that a certain degree of self-respect is one of the best securities against moral degradation.

"Dublin, Oct. 15. 1811.

"My dear Brother,

"I am just arrived, after a short passage; and I have just perused your letter. I shall enclose with this as many letters of introduction as a frank will hold. Mrs. Appreece has written to Mr. H. Mac-

kenzie's family, which she thinks the one in Edinburgh that will be most agreeable to you. Call and leave your name. You will easily find him. He is the author of the 'Man of Feeling.'

"I should not lay much stress upon the advice of a bad logician. * * * * You must follow your own plans with respect to study.

* * * * *

"Pray do not care about the expense, if it adds any thing to the comfort or the respectability of your situation. If you could board in a respectable family, it would, I think, be best.

"I will, if you like, send you 40*l.* a year in addition to what my mother sends you; and you may, if you please, consider it as a loan, which you shall repay when you are a rich physician.

"My dear John, let no difficulties alarm you. You may be what you please. Trust me, I know what your powers are. Preserve the dignity of your mind, and the purity of your moral conduct. You set sail with a fair wind on the ocean of life * * * * * * * Move straight forward on to moral and intellectual excellence. Let no example induce you to violate decorum, — no ridicule prevent you from guarding against sensuality or vice. Live in such a way that you can always say, the whole world may know what I am doing.

"I am, my dear John,

"Your ever affectionate Brother,

"H. Davy."

Soon after my brother's return to London from Ireland, new prospects opened before him full of

hope of happiness, as well as of increased power of usefulness. He had, during the preceding year, become acquainted with Mrs. Appreece, towards whom esteem gradually ripened into affection.

When their marriage was decided on, he thus wrote to my mother: —

"My dear Mother,

"You possibly may have heard reports of my intended marriage. Till within the last few days it was mere report. It is, I trust, now a settled arrangement. I am the happiest of men, in the hope of a union with a woman equally distinguished for virtues, talents, and accomplishments. * * * * * * * * You, I am sure, will sympathise in my happiness. I believe I should never have married, but for this charming woman, whose views and whose tastes coincide with my own, and who is eminently qualified to promote my best efforts and objects in life. * * * * * * * * * * *

"I am your affectionate son,

"H. Davy."

With the same strong feeling he announced his marriage to me about the same time: —

"My dear John,

"Many thanks for your last letter. I have been very miserable. The lady whom I love best of any human beings has been very ill. She is now well, and I am happy. Mrs. Appreece has consented to

marry me; and when the event takes place I shall not envy kings, princes, or potentates.

* * * * * *

"I am, my dear brother,
"Ever most affectionately yours,
"H. Davy."

The next letter was written on the eve of his marriage, and just after he had received the honour of knighthood:—

"Friday, April 10th, 1812.

"My dear Brother,

"You will have excused me for not writing to you on subjects of science. I have been absorbed by arrangements on which the happiness of my future life depends. Before you receive this these arrangements will, I trust, be settled; and, in a few weeks, I shall be able to return to my habits of study and of scientific research.

"I am going to be married to-morrow; and I have a fair prospect of happiness, with the most amiable and intellectual woman I have ever known.

"The Prince Regent, unsolicited by me, or by any of my intimate friends, was pleased to confer the honour of knighthood on me at the last levee. This distinction has not often been bestowed on scientific men; but I am proud of it, as the greatest of human genius's bore it; and it is at least a proof that the court has not overlooked my humble efforts in the cause of science.

"I have discovered pure phosphorous acid (a solid body, very volatile); and a pure hydrophosphorous acid, containing two proportions of water and four

of phosphorous acid, and decomposing by heat into phosphoric acid and a new gas containing four proportions of hydrogen and one of phosphorus. I have made some curious discoveries (economical ones) on sulphuric acid. I shall give them in my next.

"Pray address to me, Sir H. Davy, Beechwood Park, near Market St. Alban's.

"Believe me, my dear John, I shall always take the warmest interest in your welfare and happiness, and will do every thing to promote your views. I shall have some ideas on your studies soon to communicate.

"I am, my dear brother,

"Most affectionately yours,

"H. Davy."

This letter was followed soon after by the next, making me further acquainted with his plans, and giving assurance of his continued attachment to science, in reply, if I recollect right, to a hope to that effect which I expressed in congratulating him on his marriage: —

"My dear John,

"I told you I should come to the Highlands this summer, and I shall carry the plan into execution. I wrote to you to say this a few days ago. I addressed my letter Edinburgh; so that, possibly, it may be lying at the post-office.

"I trust I shall have the happiness of seeing you before the end of July; and that I shall see you well, improved, active, and happy.

"I communicated to you, in a former letter, my plans, as far as they were matured. I have neither given up the Institution, nor am I going to France;

and, wherever I am, I shall continue to labour in the cause of science, with a zeal not diminished by increase of happiness and (with respect to the world) increased independence.

"I have just finished the first part of my 'Chemistry,' to my own satisfaction, and I am going to publish my 'Agricultural Lectures,' for which I am to get 1000 guineas for the copyright, and 50 guineas for each edition, which seems a fair price. As I shall see you so soon, I shall not write about any matters of science.

"I shall bring you what I think you will consider an agreeable present,—copies of all your papers, twenty-five of each, as presents for your friends.*

"I was appointed Professor (honorary) to the Institution, at the last meeting. I do not pledge myself to give lectures. Brande gives twelve.

*   *   *   *   *   *

If I lecture, it will be on some new series of discoveries, should it be my fortune to make them; and I give up the *routine* of lecturing, merely that I may have more time to pursue original inquiries, and forward more the great objects of science. This has been for some time my intention, and it has been hastened by my marriage.

"I shall have great pleasure in making you acquainted with Lady D. She is a noble creature (if I may be permitted so to speak of a wife), and every day adds to my contentment by the powers of her understanding, and her amiable and delightful tones of feeling. God bless you.

"Believe me to be

"Your affectionate brother,

"H. DAVY."

* These were papers published in the Philosophical Transactions.

The first work alluded to, in the letter just given, as *his Chemistry*, was his "Elements of Chemical Philosophy," published very soon after his marriage. It was in many respects peculiar. In the dedication to Lady Davy, he expresses the warm feelings of his heart, and gives assurance of his lasting devotion to science. It was written during the period of his courtship, which, as he states in the same dedication, was the happiest period of his life. It was commenced in the autumn, just before he set out for Ireland, was rapidly continued amidst the various distractions of his many different occupations and pursuits, and was printed as it was written. Almost as soon as he began writing, he began printing; no fair copy was made: the MS. was transferred sometimes the same day and hour from his pen to the press; and yet I am not aware that the work bears any material marks of hastiness, or of carelessness, or of any want of systematic arrangement, or of due keeping and proportion of its parts. Though rapidly composed, it was not, in fact, hurried; he was very careful in verifying results, taking nothing for granted; and thus, in a letter written to me in the winter of 1812, speaking of this undertaking, in which he was then engaged, he says:—"The time not employed in lecturing or public occupation I devote to my book. I shall soon send you what I have done. I examine all results as I go on." His great facility arose very much from his mind having been prepared for it by his previous studies and researches, somewhat in the same manner as the hand of a great artist in design is for a fresco painting. Indeed, as a whole, it is rather to be considered an epitome of his own labours, and discoveries, and peculiar views, than what the title of Elements would indicate.

The most original and interesting parts of the work are, first, those relating to chemical attraction, and to electricity, heat and light, in connection with chemistry, viewed as chemical agents; secondly, those relating to simple substances and their primary combinations, especially chlorine, and the bases of the fixed alkalies, alkaline earths, and earths proper; and, thirdly, his views and speculations relative to the obscure parts of chemistry, its analogies, and prospects of extension. Under the head of chemical attraction he brought forward his views of the combination of bodies in definite proportions, and opposed the speculations of Berthollet of a contrary kind, relative to the influence of mass, and various other accidental circumstances, in altering the results of affinities. I must refer the chemical reader for details to the work itself. It will be sufficient here to observe that my brother, in refuting Berthollet, made a constant appeal to facts, and showed that the statements which that distinguished chemist advanced in favour of his peculiar doctrines were, either altogether or in part, incorrect; and that they owed their apparent force of argument to the omission of some particulars or circumstances which, if taken into account, admitted of the explanation of the results, on the idea that chemical attraction is entirely certain and definite in operation, neither admitting of gradation either as regards its force or its effects.

My brother's own views respecting the doctrine of combination in definite proportions were a modification of those of Mr. Dalton, — the same, in regard to fact, stripped of all speculation; in brief, merely a generalisation, or an induction from facts.

It is a fact that all compounds, the composition of which is accurately known, always consist of (as

nearly as possible) the same quantities of ingredients; the exactness of nature appearing every day more perfect as the processes of chemistry improve in accuracy.

It is a subordinate fact, that a substance, whether an acid or an alkali, an earth or a metal, an inflammable or supporter of combustion, when it is capable of effecting decompositions in consequence of superior attraction, always expels the same proportional quantity of matter endowed with an attraction inferior in force to its own; so that if it is known how much it will expel from one, it is known how much it will expel from all. Thus a metal always precipitates the same quantity of another metal, from all its solutions, that it is capable of decomposing; and thus, too, in the mutual decomposition of neutro-saline solutions, in ordinary circumstances, there is no change of the neutral point.

It is also a fact, that when one substance forms with another more than one compound, the proportion with which it combines in the second, or third, or fourth compound, is always a multiple or divisor of that in the first; and, subordinate to this, when gases combine they unite either volume with volume, or with half a volume, or with two or three. It is a generalisation of these facts which constitutes the important doctrine of bodies uniting in definite proportions. It was thus as much as possible based on experience, independent of opinion or speculation, that my brother first adopted it, and always held it. Mr. Dalton, on the contrary, advanced it originally in a different form, to which assent might be given or withheld at pleasure; he advanced it as an abstract speculation, more in the manner of an ancient than

of a modern philosopher, founding it, as he announced it, on certain axioms connected with the invisible particles of matter.

This hypothetical form was very unfavourable to the reception of the doctrine in its early stage. Dr. Thompson, in his "History of Chemistry*," states that my brother first opposed it, though he afterwards became one of its most strenuous supporters. Well acquainted with his opinion on the subject, it appears to me that Dr. Thompson has mistaken it, not distinguishing between his sentiments on the hypothetical parts of Mr. Dalton's views, the atomic doctrines relating to the weight, size, and number of atoms, and those which he held derived from the results of analysis, the facts and true foundations of the theory. The former are still, as they were at first, and as they ever must be, open to objection, being beyond the scrutiny of the senses and the test of experiment.

If my brother at any time indulged in pleasantry in conversation, on the atoms of Mr. Dalton, as mentioned by Dr. Thompson, it must have been in a guileless manner, and with no expectation that it would have been re-echoed, and still less recorded in the page of the history of chemistry. He always respected and esteemed Mr. Dalton, and never thought lightly of any of his views. The estimation in which my brother held him, as the author of the theory which has rescued chemistry from endless confusion and vagueness, is best seen in his writings. I shall quote that part of his discourse to the Royal Society which he delivered on the award of the first royal medal to Mr. Dalton, in which he does the amplest

* Vol. ii. p.193.

justice to that gentleman as an original discoverer, nowise detracting from *his* merits, as others have detracted from his own * : —

"They (the council of the Society) have awarded the first prize to Mr. John Dalton of Manchester, Fellow of this Society, for the development of the chemical theory of definite proportions, usually called the Atomic Theory, and for his various other labours and discoveries in physical and chemical science.

"What Mr. Dalton's merits are, I shall briefly endeavour to state to you, though it is impossible to do justice to them in the time necessarily allotted to this address.

"The brilliant and important discoveries of Black, Cavendish, Priestley, and Scheele had added to chemistry a great variety of substances before unknown, many of which had forms never before witnessed in the material world; and the new and accurate logic of Lavoisier had assigned to many of them their just places in the arrangements of chemistry, and had established the characters of most of them as simple or compound bodies. Novel uses of these substances were ascertained, new combinations of them made, and their applications to the purposes of common life constantly extended by various distinguished chemists in the close of the last century; but, with

* Mr. Babbage, in his Essay on the Decline of Science in England, has called the award of this medal to Mr. Dalton an insult. By what process of reasoning or feeling he has arrived at this inference it is difficult to imagine. The rules established for the awarding of the medal having been broken through by the Council of the Society in Mr. Dalton's favour (the matter of offence to Mr. Babbage, according to his own stating), is surely an enhancement of honour. It is melancholy to witness the effects of party animosity, and more especially amongst men of science; how it blinds the judgment, destroys generous sentiment, and produces all kinds of misrepresentation!

respect to the weight or quantity in which the different elementary substances entered into union to form compounds, there were scarcely any distinct or accurate data. Persons, whose names had high authority, differed considerably in their statements of results; and statical chemistry, as it was taught in 1799, was obscure, vague, and indefinite, not meriting even the name of a science.

"To Mr. Dalton belongs the distinction of first unequivocally calling the attention of philosophers to this important subject. Finding that, in certain compounds of gaseous bodies, the same elements always combined in the same proportion; and that when there was more than one combination, the quantity of the elements always had a constant relation, such as one to two, or one to three, or to four;—he explained this fact on the Newtonian doctrine of indivisible atoms, and contended that the relative weight of one atom to that of any other atom being known, its proportions or weight, in all its combinations, might be ascertained; thus making the statics of chemistry depend upon simple questions in subtraction or multiplication, and enabling the student to deduce an immense number of facts from a few well-authenticated, accurate, experimental results.

"I have said that to Mr. Dalton belongs the distinction of first unequivocally calling the attention of philosophers to this subject; but I should be guilty of historical injustice, if I did not state that various opinions and loose notions on the same mode of viewing the combinations of bodies had existed before. And not to go back to the time of the Greek schools, to the Homoids of Anaxagoras, or to the Atoms of Epicurus, nor to those Newtonian philoso-

phers who supported the permanency of atoms, and their uniform combinations; such as Keil, Friend, Hartley, and Marzucchi;—there may be found in the works of Dr. Bryan Higgins, Mr. William Higgins, and Professor Richter, hints or conclusions bearing decidedly on this doctrine. Dr. Bryan Higgins, in his experiments and observations relating to acetous acid, fixable air, dense inflammable air, fire, and light, published in 1786, contends that elastic fluids unite with each other in limited proportions only; and that this depends upon the combination of their particles or atoms with the matter of fire, which surrounds them as an atmosphere, and makes them repulsive of each other; and he distinguishes between simple elastic fluids, as composed of particles of the same kind, and compound elastic fluids, consisting of two or more particles, combined in what he calls molecules, definite in quantity themselves, and surrounded by definite proportions of heat. Dr. Bryan Higgins's notions have, I believe, never been referred to by any of the writers on the atomic theory. Mr. William Higgins's claims have, on the contrary, often been brought forward: yet, when it is recollected that this gentleman was a pupil and relation of Dr. Bryan Higgins, and that his work called the 'Comparative View' was published some years after the treatises I have just quoted, and that his notions are almost identical (with the addition of this circumstance, that he mentions certain elastic fluids, such as the compounds of azote, consisting of one, two, three, four, and five particles of oxygen to one of azote), it is difficult not to allow the merits of prior conception, as well as of very ingenious illustration, to the elder writer.

"Neither of the Higgins attempted to express

the quantities in which bodies combine by numbers; but Richter has a claim of this kind. In his 'New Foundations of Chemistry,' published in 1795, he has shown that, when neutro-saline bodies, in general, undergo mutual decomposition, there is no excess of alkali, earth, or acid; and he concludes that these bodies are invariable in their relation to quantity, and that they may be expressed by numbers.

"Mr. Dalton, as far as can be ascertained, was not acquainted with any of these publications, at least he never refers to them; and whoever will consider the ingenious and independent turn of his mind, and the original tone prevailing in all his views and speculations, will hardly accuse him of wilful plagiarism. But let the merit of discovery be bestowed wherever it is due, and Mr. Dalton will be still pre-eminent in the history of the theory of definite proportions. He first laid down, clearly and numerically, the doctrine of multiples, and endeavoured to express by simple numbers the weights of the bodies believed to be elementary. His first views, from their boldness and and peculiarity, met with but little attention; but they were discussed and supported by Drs. Thomson and Wollaston; and the table of chemical equivalents of this last gentleman separates the practical part of the science from the atomic or hypothetical part, and is worthy of the profound views and philosophical acumen and accuracy of the celebrated author.

"Gay Lussac, Berzelius, Dr. Prout, and other chemists have added to the evidence in favour of the essential part of Mr. Dalton's doctrine; and, for the last ten years, it has acquired almost every month additional weight and solidity.

"Gentlemen, I hope you will clearly understand

that I am speaking of the fundamental principle, and not of the details as they are found in Mr. Dalton's system of chemical philosophy. In many of these, the opinion of the composition of bodies is erroneous, and the numbers gained from first and rude experiments incorrect; and they are given with much more precision in later authors on chemistry. It is in the nature of physical science that its methods offer only approximations to truth; and the first and most glorious inventors are often left behind by very inferior minds in the minutiæ of manipulation; and their errors enable others to discover truth.

"Mr. Dalton's permanent reputation will rest upon his having discovered a simple principle universally applicable to the facts of chemistry — in fixing the proportions in which bodies combine, and thus laying the foundation for future labours respecting the sublime and transcendental parts of the science of corpuscular motion. His merits in this respect resemble those of Kepler in astronomy. The causes of chemical change are as yet unknown, and the laws by which they are governed; but, in their connection with electrical and magnetical phenomena, there is a gleam of light pointing to a new dawn in science; and may we not hope, that, in another century, chemistry having, as it were, passed under the dominion of the mathematical sciences, may find some happy genius, similar in intellectual powers to the highest and immortal ornament of this Society, capable of unfolding its wonderful and mysterious laws?"

On the other parts of the elements of chemical philosophy which I have alluded to as most interesting and important, little commentary is here required, the subjects of them having been more or less

specially considered in the papers which he had previously given to the Royal Society. The section on electricity is a clear abstract of all that was most valuable then known in that science, embracing electro-chemistry, and enriched with many new results tending to establish its laws.

I shall extract his account of the great voltaic battery, the effects of which were so wonderful and instructive, as well as brilliant; and I may preface it with the remark, that marvellous as the effects of this gigantic apparatus were, he had in part anticipated them as far back as 1800 or 1801. In a note-book kept at that time he observes: —

"By means of 1000 plates, you may perhaps make the spark pass through air, &c.

"The most powerful combination that exists, in which number of alternations is combined with extent of surface, is that constructed by the subscriptions of a few zealous cultivators and patrons of science in the laboratory of the Royal Institution. It consists of 200 instruments connected together in regular order, each composed of ten double plates arranged in cells of porcelain, and containing in each plate thirty-two square inches; so that the whole number of double plates is 2000, and the whole surface 128,000 square inches. This battery, when the cells were filled with sixty parts of water, mixed with one part of nitric acid and one part of sulphuric acid, afforded a series of brilliant and impressive effects. When pieces of charcoal about an inch long and one-sixth of an inch in diameter were brought near each other (within the thirtieth or fortieth part of an inch), a bright spark was produced, and more than half the volume of the charcoal became ignited to

whiteness; and by withdrawing the points from each other a constant discharge took place through the heated air, in a space equal at least to four inches, producing a most brilliant arch of light, broad and conical in form in the middle. When any substance was introduced into this arch it instantly became ignited; platina melted as readily in it as wax in the flame of a common candle; quartz, the sapphire, magnesia, lime, all entered into fusion; fragments of diamond, and points of charcoal and plumbago rapidly disappeared, and seemed to evaporate in it, even when the connection was made in a receiver exhausted by the air-pump; but there was no evidence of their having previously undergone fusion.

"When the communication between the points positively and negatively electrified was made in air, rarefied in the receiver of the air-pump, the distance at which the discharge took place increased as the exhaustion was made; and when the atmosphere in the vessel supported only one-fourth of an inch of mercury in the barometrical gauge, the sparks passed through a space of nearly half an inch; and, by withdrawing the points from each other, the discharge was made through six or seven inches, producing a most beautiful corruscation of purple light; the charcoal became intensely ignited, and some platina wire attached to it fused with brilliant scintillations, and fell in large globules upon the plate of the pump. All the phenomena of chemical decomposition were produced with intense rapidity by this combination. When the points of charcoal were brought near each other in non-conducting fluids, such as oils, ether, and oxymuriatic compounds, brilliant sparks occurred, and elastic matter was rapidly generated; and such

was the intensity of the electricity, that sparks were produced even in good imperfect conductors, such as the nitric and sulphuric acid.

"When the two conductors from the ends of the combination were connected with a Leyden battery, one with the internal, the other with the external coating, the battery instantly became charged; and on removing the wires, and making the proper connections, either a shock or a spark could be perceived; and the least possible time of contact was sufficient to renew the charge to its full intensity."

His views of the effects of radiant matter, or that species of matter which passes from the sun to the earth, were in some respects peculiar. He does not agree with MM. Gay Lussac and Thenard that the chemical operation of the sun's rays depends merely on their heating power; nor does he admit, with Dr. Wollaston and M. Berard, that the invisible rays next the violet in the solar spectrum are specifically chemical rays; he is rather of opinion that the whole ray is active, and the different parts of it when separated by the prism; and that its effects depend upon a peculiar influence, which, to be better understood, requires to be further studied. As the subject is of much interest and importance, as well as obscure, I shall transcribe his remarks on it:—

"As yet it has not been clearly demonstrated what is the peculiar chemical energy of the least refrangible rays. In acting upon the compounds of silver, they produce new combinations, or a disengagement of hydrogen by decomposing water, and they have no action whatever on these substances when dry. I found that chlorine was much more rapidly absorbed by water, and muriatic acid much more rapidly formed when the vessels were exposed in the violet

extremity of the spectrum than when they were exposed to the other rays; but that the combinations of chlorine and hydrogen in dry vessels took place more rapidly in the red rays. M. Berard has stated, however, an opposite result; but new experiments are wanting to decide the question. I made my experiment by concentrating the red rays and the rays beyond the red rays by a lens, and throwing them upon a small sphere of copper within the vessel, so that the heat communicated to the metal may have interfered with the result; and in M. Berard's trials the vessels were moist, so that his result *may* have been connected with a deposition of water.

"I found that the black oxide of mercury exposed in the red rays, concentrated by a lens, gradually became red, in which case oxygen was probably absorbed; but the same oxide exposed in the violet rays, concentrated in the same manner, was not changed; and these rays produced no effect upon dry red oxide of mercury, but upon moistened red oxide occasioned the same change as a current of hydrogen gas.

"Dr. Wollaston has shown, that a change of colour is produced upon gum guaicum by the rays beyond the violet rays, connected with an absorption of oxygen, and hence he has proposed to call the invisible rays in this part of the spectrum chemical rays, and M. Berard has adopted this distinction; but, supposing that hydrogen is disengaged in the experiment on guaicum, it may in its nascent state absorb oxygen, and the change of colour may depend, not upon the absorption of oxygen, but the separation of hydrogen and its new combination.

"The facts that I have stated above sufficiently

demonstrate that the rays producing heat are capable of assisting certain species of chemical action; and there seems no more reason for asserting that the rays producing no heat are the rays most efficacious in occasioning chemical changes, than for asserting, with MM. Gay Lussac and Thenard, that light produces all its chemical effects by producing heat." *

That part of his work which related to the simple or elementary substances, or those bodies which had not been decompounded, had a very original character, in consequence of the results of his own inquiries. Without hesitation, he places the bases of the fixed alkalies, and alkaline earths, and earths proper, in the class of metals, and took away oxymuriatic acid gas from the class of acids, to which it had been so long spellbound by the power of hypothesis and of a hypothetical nomenclature; and, with a name independent of speculation, placed it by the side of oxygen, as most analogous to it in its general properties. This classification was by some critics objected to at the moment, and considered premature; but, as they were moved rather by timidity and fear of change than the force of truth, their opposition was little regarded, and is now forgotten; and the arrangement then, for the first time, proposed in an elementary work, is now, I believe, almost universally received.

The change of doctrine concerning oxymuriatic acid gas, and the new views connected with chlorine, naturally made my brother anxious to see effected a reform in nomenclature. It has been already mentioned how he proposed to designate the combinations

* MS. for 2d edition.

of this substance. He brought forward the same proposition in his Elements, and used the names which he had suggested; but, finding that they were not approved of by men of science, it was his intention to have omitted them in the second edition of his work.

The subject of chemical nomenclature generally, he was of opinion, required a thorough revision. He considered the principle of the French nomenclature, as it is commonly called, ill adapted to a progressive science; liable to great abuse; an obstacle in the way of discovery, and fitted only for the state of chemistry when it was invented. At a very early period he entertained these sentiments respecting it, even before he left Penzance; and in a note-book kept at Bristol they are strongly expressed. As the topic is still unsettled, and deserving of very mature consideration and careful discussion, I shall give some of his views respecting it; hoping that they may have an influence in the formation of a nomenclature, which, as is so much to be desired, shall be permanent, amidst the changes and advancement of science; and if not a help to the memory, at least not a clog to the understanding, and an impediment to truth.

He seems to consider it essential, first, that names should have no reference to inaccurate generalisation; secondly, that they should be derived, not from a group of properties, but from some simple and obvious property; and, thirdly, that they should be as simple and brief as possible.

I shall select two or three of his remarks, which illustrate his views of nomenclature, whilst they show how little his own mind was biassed by the theory connected with the French nomenclature: —

" If the names of substances are to be formed from

their properties, they should be from properties which are readily perceived, and which have no relation to a number of facts.

"It is wrong to assume facts which can only be known by experience. Water ought, on the principles of the French nomenclature, to be called oxide of hydrogen. Let us translate the combinations of hydrogen—water generator, oxide of water generator. Here, it is evident, we oblige the reader to form an idea of a compound substance, that he may be able to understand the species of a simple one; and we likewise oblige him to form a number of imperfect ideas with regard to the mode of this formation. So too, of oxygen: a person, unacquainted with this substance, must go through a succession of chemical facts to comprehend the name. But it is not by the acidifying power of oxygen gas that the experimentalist detects its existence; it is by its non-absorbability by water, diminution with nitrous gas, and capability of supporting flame. The name, instead of conveying to the mind of a student a clear and determinate idea, as Lavoisier supposes, calls up trains of obscure ideas, connected with an imagined process of acidification.

"Besides, after any one has been accustomed to apply the term generator of acid properties for some time to a particular substance, he is induced to believe its existence in all bodies possessed of these properties; is thoroughly convinced of its existence in the muriatic, fluoric, and boracic acids; and is astonished that sulphuretted hydrogen can exist as an acid without it."

The next extract is from a Lecture of 1811, on oxygen: —

"The whole series of discussions that have been brought forward prove that oxygen is a body very prone to enter into combination, and with great energy, and usually produces light, and always heat. The compounds that it forms differ according to the nature of the body with which it combines. Thus, with hydrogen, it forms a neutral compound; with sulphur, a strong acid; with potassium, a corroding alkali; with iron, an insoluble tasteless body; and with certain metals it forms earths. Oxygen, therefore, or the producer of acid, is a very improper name for it; for there are many powerful acids that do not contain it, and it exists in the most energetic alkalies. It might be called with more propriety hydrogen, the producer of water, or alkaligen, or geogen; but all these names are equally exceptionable. At present it is better to continue the name of oxygen, and to wait for a more mature period of the science for the reform of the nomenclature."

Other extracts might be given in exemplification of his views of nomenclature; but these may suffice, as all his observations were rather pointed at the imperfections of the French system, than directed to the formation of a new one. Indeed, both then, and always after, he considered chemistry too unsettled to receive a nomenclature founded on strict principles of science. He considered a loose nomenclature, fettered as little as possible by theory, best fitted for its youthful and growing state. Such names as chlorine, euchlorine, phosgene, nowise descriptive of the chemical nature of the substances to which they were applied, he preferred to others which theory would have suggested; and on the same principle, I believe, he preferred popular

names and old names, when, if at all, significant only, of some obvious quality, or expressive of the names of discoverers; such as corrosive sublimate, calomel, litharge, minium, aurum musivum, the fuming liquor of Libavius, Kermes mineral, &c.— to appellations derived from theory, and respecting the propriety of which, till the science were perfect, there might be unceasing difference of opinion. Perhaps a nomenclature of a mixed kind, such as is commonly employed in mineralogy and geology, and indeed in all the other sciences, is most suitable to chemistry, would serve best the purpose of science and its interests, and would be most commodious for common use.

Not only the discoveries which had been made since the promulgation of the French nomenclature rendered my brother averse to its principle, but also the anticipations which he indulged in of further and greater advances. Some idea of this may be formed from the concluding part of his work, to which I must refer the curious reader. He laid it down as an axiom, that "we know nothing of the true elements belonging to nature:" he considered nature as inexhaustible, affording matter for almost endless research, limited only by the powers of the mind. Full of hope of continued triumphs of experimental science and the discovery of some simple law applicable to the complicated phenomena of chemistry, it is not surprising that he was averse to a nomenclature, the tendency of which is opposed to change, as if, when first established, it had been taken for granted that the science was perfect.

I have occasionally referred to a MS. which my brother had prepared for a second edition of the Ele-

ments of Chemical Philosophy, consisting of some additions and some alterations, and a few corrections, but none of them of very material importance.

It seems singular that though the work was in much estimation when it appeared, and continues to be valued and quoted as of high authority by the best writers on chemistry, and though it was translated into most European languages, yet a second edition of it has not been required.

As he stated in the first edition, and repeated in the copy prepared for the second, it was his intention to have continued and completed the work. He also stated in the latter his intention of shortly giving to the public a distinct work, containing a detailed account of his labours in analytical chemistry carried on during the preceding twelve years. Whether he commenced a second volume of his Elements, or the work last mentioned, I am not sure; I believe not; I can find no traces of either of them. The intention, however, he never entirely relinquished; and had his life been prolonged, and his health permitted, I have no doubt he would have carried it into effect. Whilst he preserved his health, that is, from 1812 to 1826, other objects of original research and more pressing interest almost constantly had his attention; and afterwards, when his health failed him, he found himself unequal to an undertaking which, whether the continuation of the Elements of Chemical Philosophy, or an account of his analytical labours, would have required a devotion of time, and attention, and exertion incompatible with a valetudinary state.

To return to the narrative. Almost immediately after his marriage he resumed his habits of re-

search; and, indeed, followed, as far as change of circumstances from his single state would admit of, the same tenor of life as before.

In the June following he gave proof of his uninterrupted zeal in the cause of science, by a paper which he then communicated to the Royal Society, entitled, "On some Combinations of Phosphorus and Sulphur, and on some other Subjects of Chemical Inquiry." And even when he set out on a tour of pleasure with Lady Davy, in the next month, for the Highlands of Scotland, he was provided with a portable chemical apparatus, that he might not be without the means of following his favourite pursuit of experimenting, in connection with fishing and shooting, which he almost as much delighted in. It was his intention to have returned to London in December; but a letter which he received from Paris, from M. Ampere, mentioning a discovery which interested him much, viz. a new detonating compound of chlorine and azote, I believe, induced him to retrace his steps earlier. Be this as it may, in the latter end of October he was again in his laboratory, and intent on the preparation of the new compound, of which he had only received from his correspondent the brief intimation that it was a fluid, exploding at the heat of the hand, and that it had deprived M. Dulong, the author of the discovery, of an eye and a finger.

The following is a paragraph from a letter which I received from him at this time, relative to this and other inquiries:—

"There is nothing doing here. I have commenced some experiments. I am attempting to decompose hydro-fluoric acid by chlorine, and to combine azote

from prussic acid with chlorine. I heated this day diamond powder in chlorine, but there was no action."

In another paragraph of the same letter, alluding to some experiments which we had made together in Edinburgh, in the laboratory of Dr. Hope, in the presence of that gentleman and some other men of science, on the union of muriatic acid gas and ammonia, in connection with the controversy then going on respecting the nature of oxymuriatic acid gas, between Dr. Murray and myself, he says:—

"I think you should answer Murray's assertion by a short note, with testimonials. The controversy is closed." He concluded this letter with the cheering exhortation, "Go on, and prosper in all good things,—in usefulness, happiness, and knowledge."

I shall insert the next letter I had from him entire, announcing his success in making the fulminating compound he was in quest of, and the wound he had received in his eye from its explosion, written, as Lady Davy added in a postscript, to save me from anxiety:—

"London, Nov. 16. 1812.

"My dear John,

"I have discovered the mode of making the combination of azote and chlorine. It is by exposing chlorine to a very weak solution of ammonia, or to a solution of nitrate of ammonia, or of oxalate of ammonia.

"It must be used with very great caution. It is not safe to experiment upon a globule larger than a pin's head. I have been severely wounded by a piece

scarcely bigger. My sight, however, I am informed, will not be injured. It is now very weak. I cannot see to say more than that I am,

"Your very affectionate brother,

"H. Davy."

This accident happened at Tunbridge, in Mr. Children's laboratory; and, as a caution to others, on his return to town, which was immediate, he communicated the particulars to the Royal Society, in a letter to Sir Joseph Banks. The injury of his eye was severe, and for a considerable time prevented him from prosecuting his labours of research. Thus, in a letter dated Wimpole, January 17th, 1813, where he was spending a few days at Lord Hardwicke's, he writes me: —

"I have had another severe attack of inflammation in the eye, and was obliged to have the conjunctiva and cornea punctured. I suspect the cause was some little imperceptible fragment. I am just recovering, and hope I shall see as well soon as with the other eye.

"My operations and employments have been, in a great measure, suspended; yet I have found opportunities of working a little upon fluorine. I believe I have nearly got to the bottom of this difficult question, and have expelled fluorine by chlorine, though I have not yet seen it, but I have ascertained that it expels oxygen from most compounds.

"I will give you my processes in my next letter."

The complete recovery of his eye was protracted nearly till April, as appears from the following letter descriptive of his plans and pursuits: —

"April 4. 1813.

"My dear John,

"It is long since I have heard from you. I am going into Cornwall. Pray address a letter to me, at Penzance. We are going, a pretty large party, into the west, and shall fish in our way. I wish you were amongst us. I shall be absent from town about three weeks. We have come to the resolution of going to Scotland in the summer. Lady D. and I shall have the pleasure of seeing you there. We think of going by Edinburgh, and of passing a good deal of our time in Sutherland; so that I have come to the resolution of seeing my mother and sisters in the spring. The Cornish journey will be too rapid a one, and too interrupted for Lady D. to be of the party. Blake, Warburton, Pepys, and the Sollys form a party who will combine mineralogy and fishing.

"I am now quite recovered, and Jane is very well, and we have both enjoyed the last month in London. I have been hard at work. I have expelled fluorine from fluate of lead, fluate of silver, and fluate of soda, by chlorine. It is a new acidifier, forming three powerful acids; hydro-fluoric, silicated fluoric, and fluo-boric. It has the most intense energies of combination of any known body, instantly combining with all metals, and decomposing glass. Like the fabled waters of the Styx, it cannot be preserved, not even in the ape's hoof. We have now a triad of supporters of combustion.

"I have just finished printing my agricultural lectures. I shall send you a copy as soon as I can.

"Thenard has proved Lampadius's liquor to be what Clement and Desormes thought, — carbon and

sulphur, fifteen to eighty-five; nearly two proportions of sulphur to one of carbon.

"Remember me to Mr. Playfair when you see him, and to the Mackenzie family, and to the Fergussons. We hope to see Mr. Playfair in May. We shall see you, if all things do well, in July.

"I am, my dear John,

"Your most affectionate brother,

"H. D.

"Remember me to Mr. Moore. I want to try some experiments before I write to him on his subject. Tell him this. Till within the last fortnight my eye has interfered with writing."

In the autumn of this year, finding it possible, on account of his scientific name, to obtain permission from the French government to visit the Continent, he formed a plan of an extensive tour with scientific objects in view, as well as the gratification of an ardent curiosity, and love of travel, which he soon carried into effect. The following is part of a letter which he wrote to his mother when on his way to embark at Plymouth: —

"Andover, Oct. 14. 1813.

"My dear Mother,

"We are just going to the Continent upon a journey of scientific inquiry, which I hope will be pleasant to us, and useful to the world. We go rapidly through France to Italy, and from that to Sicily; and we shall return through Germany. We have every assurance from the governments of the countries through which we pass, that we shall not

be molested, but assisted. We shall stay probably a year or two.

*   *   *   *   *   *

"As soon as I have settled a plan of correspondence abroad, I will write to you, and shall hear of you from John as often as possible. As I am permitted to pass through an enemy's country, there must be no politics in any letters to me; and you had better not write except through the channel I shall hereafter point out.

*   *   *   *   *   *

"When I return I shall peacefully fix my abode for life in my own country. Pray take care of Betsy. When the wind is cold she should not think of going out. Tell Grace not to be afraid, though I am going through France. My love to Kitty, and to Grace and Betsy. I am, my dear mother, wishing you all health and happiness,

"Your very affectionate son,

"H. Davy."

The following day I had a letter from him from Plymouth; from whence, with Lady Davy, he crossed the channel in a cartel to Morlaix. He was accompanied by Mr. Faraday (who has since so honourably distinguished himself in original research) as his assistant in experiments and in writing*, and provided with a commodious portable apparatus for instituting such inquiries as he had in contemplation.

* Mr. Faraday's Letter to Dr. Paris. "Life," &c. ~~p. 263.~~ Vol II p 2

CHAPTER IX.

NOTICES OF HIS FIRST CONTINENTAL TOUR. — RESEARCHES ON IODINE AT PARIS. — SKETCHES OF DISTINGUISHED FRENCHMEN, GUYTON DE MORREAU, VAUQUELIN, CUVIER, DE HUMBOLDT, GAY LUSSAC, BERTHOLLET, LA PLACE.—VERSES ON "FONTAINEBLEAU," ON "MONT BLANC," "THE BANKS OF THE RHONE," "THE MEDITERRANEAN PINE," "THE CANIGOU," "VAUCLUSE," "CARRARA." — SCIENTIFIC RESEARCHES ON HIS JOURNEY. — VERSES ADDRESSED TO CANOVA; ON "THE SYBIL'S TEMPLE;" ON "A DISTANT VIEW OF PÆSTUM." — MENTION OF VOLTA. — EXTRACT FROM HIS JOURNAL. — DESCRIPTION OF PART OF THE TYROL. — OCCUPATIONS AT ROME IN THE WINTER OF 1814. — EXPERIMENTS ON THE COLOURS OF THE ANCIENTS. — A MIS-STATEMENT RESPECTING HIM POINTED OUT RELATIVE TO A CONTROVERSY WITH M. GAY LUSSAC. — EXTRACTS FROM HIS JOURNAL. — ANECDOTE OF HIM FURNISHED BY SIR WALTER SCOTT. — HIS RETURN TO ENGLAND.

I SHALL commence this chapter with a quotation from his "Consolations in Travel," descriptive, in a few words, of the period of his life that has passed in review, and of that on which we are about to enter: —

"Accident opened to me, in early youth, a philosophical career, which I pursued with success. In manhood fortune smiled upon me, and made me independent. I then really became a philosopher, and pursued my travels with the object of instructing myself, and of benefiting mankind. I have seen most parts of Europe, and have conversed, I believe, with all the illustrious men of science belonging to them. My life has not been unlike that of the ancient Greek sages. I have added some little to the quantity of human knowledge, and I have endeavoured to add something to the quantity of human happiness."

The following letter to my mother was written a day or two after his arrival in France: —

"Morlaix, Oct. 22. 1813.

"My dear Mother,

"We are safe at Morlaix. A sea voyage is always disagreeable, and I have not yet recovered the effects of mine. We were a day and two nights at sea. We found here our passport from Paris, and we shall set out to-morrow. The weather is rather unfavourable; but it has rained so much, that I hope the clouds are exhausted.

"Pray write to my brother, and say to him that we are quite safe. As soon as I arrive in Paris, I shall endeavour to find a mode of hearing as often as I can of your health and safety.

"I am, my dear mother,

"With best love to my sisters and aunt,

"Your very affectionate son,

"H. Davy."

In Paris he spent about two months, variously occupied between the calls of society and of science. During this short period he had the pleasure of being instrumental in adding another substance to the supporters of combustion, viz. iodine; the nature of which he first determined in a satisfactory manner. It had been discovered two years before by M. Curtois, a manufacturer of saltpetre, but kept a secret. About the time of my brother's arrival, MM. Clement and Desormes were engaged in examining it, at the desire of M. Curtois, and had ascertained many of its properties; and M. Gay Lussac had also entered on the inquiry. The most

striking quality of iodine,— that by which it was discovered, and to which it owes its name*,— is its becoming a violet-coloured gas when heated. Another quality which fixed the attention of those who examined it was, its forming an acid having the character of the muriatic acid. M. Clement, indeed, believed that it was really the muriatic acid, and M. Gay Lussac entertained the same opinion. At the request of the former, my brother, who had received a small portion of the problematical substance from his friend, M. Ampere, submitted it to experiment, and soon satisfied himself that the acid just alluded to is distinct from the muriatic, and a new and peculiar one; and that iodine itself is a simple substance, analogous in its chemical relations to chlorine.

These views of the nature of iodine and its acid were communicated to M. Gay Lussac; and it was not till after this distinguished chemist was well acquainted with them, and after further research, that he gave up his first idea.†

The analogy between iodine and chlorine imparted to the former substance a peculiar interest, and very much facilitated the investigation respecting it. The contrast was great between the previous slowness and the subsequent rapidity of progress of the inquiry. In a few days my brother had ascertained some of its most remarkable properties and combinations, and had collected the materials of his first communication to the Royal Society on the subject; and in less than twelve months, chiefly in consequence of the elaborate and masterly researches of M. Gay

* From ιωδης, violaceous.

† Vide Journal of Science and the Arts, vol. i. p. 284.

Lussac, the chemical history of iodine was more full and complete than that of most other substances longest known.

The manner in which my brother conducted the investigation (and I must confine myself to his labours) was very much after the plan of that which he followed in the examination of chlorine. I shall notice only briefly his principal experiments and results, referring the chemical reader to his paper published in the Philosophical Transactions for 1814, for the minute details. After having satisfied himself that the questionable acid was not the muriatic, and that iodine is capable of uniting immediately with silver, and that the compound is the same as that which its acid precipitates from nitrate of silver, his next object was to endeavour to decompose iodine. For this purpose he successively tried the action of potassium, of chlorine, and of oxygen on it, with the hopes of separating either an inflammable base, or oxygen, or chlorine, did it contain any of these principles; but in vain. With the two first substances it entered immediately into union, — with potassium forming a white saline body, and with chlorine a yellow solid, volatile by heat, soluble in water, and possessed of acid properties; whilst with oxygen it remained unaltered.

MM. Clement and Desormes had ascertained that iodine is capable of entering into combination with most of the metals, and they stated that metallic oxides might be obtained from their solutions. This my brother verified; but he found that no oxide could be obtained unless water was present, or a substance known to contain oxygen.

His attention was next directed to the action of

phosphorus on iodine, and the peculiar acid gas, since called the hydriodic, which is produced when these two substances are heated together. He found that the quantity of this acid is, in some measure, proportional to the moisture present; that, when water is as carefully as possible excluded, very little acid results from the union of the phosphorus and iodine; that, when sufficient moisture is present, the production of it is abundant; that it may be procured also by heating the phosphuret of iodine with a little water, and may be procured directly by heating iodine in hydrogen gas; and further, that when the acid gas is decomposed by potassium or any other metal, as happens with muriatic acid gas, hydrogen is liberated equal to half the volume of the gas, and a compound of the metal used and iodine is formed, precisely the same as that which is obtained by uniting iodine with the metal directly.

MM. Clement and Desormes had ascertained that iodine is rapidly soluble in a solution of potash. My brother, reasoning on the circumstances of the experiment,—that the iodine dissolves without the disengagement of oxygen gas, and that the compound obtained by evaporating and heating the solution is the same as when iodine and potassium are united directly, — inferred that iodine must be capable of forming a class of salts analogous to those which were formerly called the hyperoxymuriates, in which oxygen exists in a very unusual proportion. This inference was fully confirmed by experiment. He obtained with facility the salt he was in quest of, and not only in the instance of potassa, but also in that of soda and barytes; and in each instance it possessed properties analogous to the corresponding hyperoxy-

muriate or (as these salts are now called) chlorate. He concluded his experimental inquiry by subjecting iodine in the gaseous state to the action of sparks from ignited points of charcoal kindled by the voltaic battery. The result was negative; the iodine remained unaltered. And not having been able to decompose it, he was compelled to consider it a simple body. And it being a non-conductor of electricity, and possessed of negative electrical energy with respect to metals, inflammable and alkaline substances, and analogous, in its general chemical qualities, to oxygen and chlorine, he did not hesitate to suggest its being placed in the same class, especially as it agrees with chlorine and fluorine in forming acids with hydrogen, and agrees with oxygen in forming an acid with chlorine. He adds, that he hopes the new facts connected with iodine "will do something towards settling the opinion of chemists respecting the nature of acidity, which seems to depend upon peculiar combinations of matter, and not on any peculiar elementary principle;" and no doubt they had this effect, and were also very efficient in support of the new doctrine concerning chlorine, which from this time came into general adoption.

Of his sojourn in Paris I have no particulars of any interest to communicate; he at this period kept no notes of what he observed, — nor, indeed, was it ever his practice in great cities. During his last illness he amused himself with writing or dictating notices of the distinguished men of science whom he had known. I may here introduce a few instances of them, — a few of the most conspicuous and distinguished with whom he had the honour of becoming acquainted during his visit to the French

capital, — most of whom, like himself, have paid the debt of nature. Slight as these sketches are, they may amuse the reader, as well as show my brother's perception of character, and the manner in which he estimated men; and, moreover, I trust they may be influential in repelling certain ungenerous, and, I believe, unjust charges which have been brought against him, of holding in contempt the talent of others, and overrating his own.

" *Guyton de Morveau* was very old when I made his acquaintance, between seventy and eighty, and very feeble. Though he had been a violent republican, he was Bonaparte's director of the mint, and a baron of the empire. His manners were mild and conciliatory; and it is a proof of the energy of his mind, that, having promised his vote to a person as corresponding member of the Institute, he kept his promise, and my election wanted only his voice to be unanimous. Having never, when in France, inquired into the intrigues connected with elections, or interested myself about them, I should not have known this, had he not himself told me so when I dined afterwards at his house."

" *Vauquelin* was in the decline of life when I first saw him in 1813,—a man who gave me the idea of the French chemists of another age; belonging rather to the pharmaceutical laboratory than to the philosophical one: yet he lived in the Jardin du Roi. Nothing could be more singular than his manners, his life, and his ménage. Two old maiden ladies, the Mademoiselles de Fourcroy, sisters of the professor of that name, kept his house. I remember the first time that I entered it, I was ushered into a sort of

bed-chamber, which likewise served as a drawing-room. One of these ladies was in bed, but employed in preparations for the kitchen; and was actually paring truffles. Vauquelin wished some immediately to be dressed for my breakfast, and I had some difficulty to prevent it. Nothing could be more extraordinary than the simplicity of his conversation; — he had not the slightest tact, and, even in the presence of young ladies, talked of subjects which, since the paradisaical times, never have been the objects of common conversation."

"*Cuvier* had even in his address and manner the character of a superior man; — much general power and eloquence in conversation, and a great variety of information on scientific as well as popular subjects. I should say of him, that he is the most distinguished man of *talents* I have known; but I doubt if he is entitled to the appellation of a man of genius."

"*De Humboldt* was one of the most agreeable men I have ever known; social, modest, full of intelligence, with facilities of every kind: almost *too fluent* in conversation. His travels display his spirit of enterprise. His works are monuments of the variety of his knowledge and resources."

"*Gay Lussac* was quick, lively, ingenious, and profound, with great activity of mind, and great facility of manipulation. I should place him at the head of the living chemists of France."

"*Berthollet* was a most amiable man; when the friend of Napoleon even, always good, conciliatory,

and modest, frank and candid. He had no airs, and many graces. In every way below La Place in intellectual powers, he appeared superior to him in moral qualities. Berthollet had no appearance of a man of genius; but one could not look on La Place's physiognomy without being convinced that he was a very extraordinary man."

"*La Place*, when a minister of Napoleon, was rather formal and grand in manner, with an air of protection rather than of courtesy. He spoke like a man not merely feeling his own power, but wishing that others should be immediately conscious of it. I have heard, from good authority, that he was exceedingly proud of his orders, and that he had the star of the order of Re-union affixed to his dressing-gown. This was in 1813. In 1820, when I saw him again, his master had fallen. His manners were altered. He was become mild and gentlemanlike; and had a softer tone of voice, and more grace in the forms of salutation. I remember the first day I saw him, which was, I believe, in November, 1813. On my speaking to him of the atomic theory in chemistry, and expressing my belief that the science would ultimately be referred to mathematical laws, similar to those which he had so profoundly and successfully established with respect to the mechanical properties of matter, he treated my idea in a tone bordering on contempt, as if angry that any results in chemistry could, even in their future possibilities, be compared with his own labours. When I dined with him, in 1820, he discussed the same opinion with acumen and candour, and allowed all the merit of John Dalton. It is true our positions had changed. *He* was

now amongst the old aristocracy of France, and was no longer the intellectual head of the new aristocracy; and, from a young and humble aspirant to chemical glory, I was about to be called, by the voice of my colleagues, to a chair which had been honoured by the last days of Newton."

These few sketches may suffice at present. He gave many more, both of foreigners and his countrymen, some of which will be introduced in the sequel; and all of which were written in the same temperate tone, and (as it appears to me) discriminative manner; biassed, if at all, by a feeling of kindness, never by one of envy or animosity.

In prosecution of his travels, he left Paris, on the 23d of December, on his way to the south of France, and to Italy. Though he made no notes of his journey which remain, he has left some memorials of it, partly in verse, expressive of his feelings, and descriptive of certain spots and things which impressed him strongly, and partly in the results of scientific research. Some specimens of the former require a place here. The first I shall insert was written on the evening of the day he commenced his journey, and at Fontainebleau, after having witnessed the varied magnificence of forest and palace, under peculiar circumstances of time and season, — when an icy foliage covered the trees, and only a few months before the abdication of Napoleon, at this very place, of whose downfall, "never to rise," he had a presentiment, the expression of which, as he afterwards told me, he considered a prophecy.

"FONTAINEBLEAU.

"Dec. 29. 1813.

"The mists disperse, — and where a sullen cloud
Hung on the mountain's verge the sun bursts forth
In all its majesty of purple light.
It is a winter's evening, and the year
Is fast departing; yet the hues of heaven
Are bright as in the summer's warmest month.
It is the season of the sleep of things;
But nature in her sleep is lovely still!
The trees display no green, no forms of life;
And yet a magic foliage clothes them round, —
The purest crystals of pellucid ice,
All purple in the sunset. Midst the wood
Fantastically rise the towering cliffs,
That in another season had been white,
But now, contrasted with the brilliant ice,
Shine in aërial tints of purest blue!
The varied outline has a thousand charms;
Here, rises high a venerable wood,
Where oaks are seen with massy ice girt round,
And birches pendant with their glittering arms,
And graceful beeches clinging to the soil;
There, massy forms exist of rocks alone,—
Rising as if the work of human art,
The pride of some great Paladin of old,
In awful ruins. Nearer I behold
The palace of a race of mighty kings;
But now another tenants. On these walls,
Where erst the silver lily spread her leaves —
The graceful symbol of a brilliant court —
The golden eagle shines, the bird of prey, —
Emblem of rapine and of lawless power:
Such is the fitful change of human things:
An empire rises, like a cloud in heaven,
Red in the morning sun, spreading its tints
Of golden hue along the feverish sky,
And filling the horizon; — soon its tints
Are darken'd, and it brings the thunder storm,—
Lightning and hail, and desolation comes;
But in destroying it dissolves, and falls
Never to rise!" —

The next, I believe, was written at Lyons, on first viewing the distant Mont Blanc in the twilight from the banks of the Rhone: —

"MONT BLANC.

"Jan. 5. 1814.

"With joy I view thee, bathed in purple light,
Whilst all around is dark; with joy I see
Thee rising from thy sea of pitchy clouds
Into the middle heaven,—
As if a temple to the Eternal, raised
By all the earth, framed of the pillar'd rock,
And canopied with everlasting snow!—
That lovely river, rolling at my feet
Its bright green waves, and winding 'midst the rocks,
Brown in their winter's foliage, gain'd from thee
Its flood of waters; through a devious course,
Though it has laved the fertile plains, and wash'd
The cities' walls, and mingled with the streams
Of lowland origin, yet still preserves
Its native character of mountain strength,—
Its colour, and its motion. Such are those
Amongst the generations of mankind
To whom the stream of thought descends from heaven,
With all the force of reason and the power
Of sacred genius. Through the world they pass
Still uncorrupted, and on what they take
From social life bestow a character
Of dignity. Greater they become,
But never lose their native purity."

"BANKS OF THE RHONE.

"Jan. 6.

"The air is soft as in the month of June
In northern climes; a balmy zephyr blows,
And nothing speaks of winter's harshest month
Save that the trees are leafless, and yon Alps,—
Not, as in summer, merely capp'd by snow,
But deep incased, and girt around by ice.
Upon the mountains crowded round thy banks,
O lovely Rhone! no ice, no snows are seen,
But lively tints and varied, such as might
Bespeak autumnal days. The oak, that long
Has kept its faded foliage, clothes thy base,—
The bracken to their sides a richer tint
Of chesnut gives, and the green herbage clothes
Their summits bathed in dew; save where the cliff
Uplifts its marble crest of hue diverse
And varied outline, grey with moss, or blue,
In native colouring; or, changed by time,
And rusted by the active elements,
More lovely in decay,—assuming forms

Of broken columns, and of mouldering towers.
Thy nearest banks, O lovely river! glow
With the bright willow, round whose crimson buds
The water-fly expands her glittering wings.
Thy upper slopes the graceful myrtle skirts,
Green as in spring time; and the primrose lurks
Beneath its odorous leaves. The fruitful vine
Darkens thy champaign, and on many a hill
The villages in sober colours rise,
The castles' towering walls; and all the tints
Which human art bestows upon the scene
Are chaste as if the master-hand of Claude
Had traced upon the canvass their design.
From the deep gullies bosom'd in thy rocks
Descends in foam and thunder many a stream
Without a name; but one is far renown'd —
Sorgue, — beside whose crystal waters sang
The bard of Provence."

The next lines are on a tree he much delighted in, the stone pine, of Italy, which, wherever it occurs, is beautiful, whether solitary amidst the vine-clad hills bordering the Campagna of Rome, or collected in groves and forests, as in the Pineta of Ravenna: —

"THE MEDITERRANEAN PINE.

"Montpelier, Jan. 14. 1814.

"Thy hues are green as is the vernal tint
Of those fair meads where Isis rolls along
Her silver floods. And not amongst the snows,
Nor on the hoary mountain's rugged crest,
Is thy abode; but on the gentle hill,
Amongst the rocks, and by the river's side,
Rises thy graceful and majestic form,
Companion of the olive and the vine,
And that Hesperian tree whose golden fruit
Demands the zephyr warmed by southern suns.
In winter thou art verdant as in spring,—
Unchangeable in beauty; and thy reign
Extends from Calpe to the Bosphorus.
Beneath thy shade the northern African
Seeks shelter from the sunshine; and the Greek,
In Tempe's vale, forms from thy slender leaves

A shepherd's coronal. Fanes of the god
Of Egypt and of Greece majestic rise
Amidst thy shades ; and to the memory,
Oh lovely tree ! thy resting-places bring
All that is glorious in our history, —
The schools where Socrates and Plato taught, —
The rocks where Grecian freedom made her stand,—
The Roman virtue, — the Athenian art, —
The hills from which descended to mankind
The light of faith, — from which the shepherd gave
The oracles of heaven, and Israel saw,
The sacrificial offering of her guilt,
The blood of the atonement, shed in vain,
When Salem fell, and her offending race
Were scatter'd as the dust upon the blast."

The next verses are dated "Oriental Pyrenees, January 26th." The record they contain of his strong patriotic feeling and love of civil liberty was called forth by seeing a British fleet in the Mediterranean, and in anticipating the overthrow of a military despotism, which, had it prevailed, might, as he apprehended, have rendered Europe again almost barbarous : —

"THE CANIGOU.*

"MORNING.

" In the eastern sky the stars their lustre lose
In more diffused light, as if their orbs
Had melted into air, and form'd the day :
Above, the heavens receive a brighter tint
Of purest azure ; and beneath they glow
With lovely hues, which every instant change,—
Now purple, and now orange ; and a gleam
Of golden light pours on the tranquil main.
I cast my eyes upon thy western coast,
And lo ! thy giant form, O Canigou !
As if a new creation of the day,
Framed of the morning cloud for ever fix'd,
And gilded by the expiring morning star.
So bright thy glittering snows appear, they seem
To form another dawn : thy base is dark,
Rising through mists that mingle with the wave !

* The Canigou is one of the highest mountains of the Pyrenees, nearly 9000 feet above the level of the sea (1491 toises).

"NOON.

"The orb of light its flood of lustre pours
From the mid-heavens upon the tranquil sea
Without a tide, whose silver mirror spreads
Reflecting forms of mountain-majesty
Along the Iberian coast; and, more remote,
In gentle agitation feels the breeze,
That to its deep and lovely azure gives
The life of motion. All the morning mists
Have vanish'd, and the mid-day sunbeams sleep
Upon thy snows, or glitter where the streams
They feed with crystal waters pour in foam
Amidst thy dark deep glens and shaggy woods,
Where the bright pine and darker cork trees blend:
Their varied foliage forms a boundary
Where winter seems to mingle with the spring.
And, lower still, the olive tree appears —
The work of culture, and the leafless vine,
And the green meadows, where the torrents sleep,
Or move obedient to the wants of man.
Nature in savage wildness, — mountain strength,—
Breathes in one picture with the forms of art,
And all that stamp the social character.
A city's walls majestically rise,
The guardian of a realm whose sounds of war
Alarm the ear. Along the sandy shore
The path the Carthaginian trod appears,
When from the Pyrennees his veterans pour'd,
To try the strength of Rome, and shed profuse
Her patriot blood at Cannæ. On the wave
Triumphant ride the fleets of Ocean's Queen.
My heart throbs quicker, and a healthful glow
Fills all my bosom. Albion, thee I hail! —
Mother of heroes! mighty in thy strength!
Deliverer! from thee the fire proceeds
Withering the tyrant; not a fire alone
Of war destructive, but a living light
Of honour, glory, and security, —
A light of science, liberty, and peace!

"EVENING.

"A moment past the sky was bright and clear,
But now a mist obscures the ambient air;
The mist becomes a cloud, which gathers round
Thy brow; at first so white, — so bright, — so pure,—
The snows seem dark beneath its crisped fringe;
And now it spreads a thicker canopy,
And rapidly descends, and fills thy glens,

And covers all thy rocks. Its tints are changed,
Its fleecy whiteness gone; the sunbeams fade,
And lose their glory in its sullen gloom,
Portentous of the storm! And now the rain
Descends in floods — the angry lightning gleams,
The thunder roars; the tempest howls along
Thy echoing cliffs; and the vexed main
Mingles her white foam with the troubled floods,
The torrents from the mountains rolling down!"

The following lines on Vaucluse were written, I believe, in the beginning of February, when he visited the remarkable, beautiful, and impressive scene of which they are descriptive,—a scene in all its features suited to his tastes and feelings, especially the river, which, of the purest water of the hue of the beryl, bursts from the base of a mountain precipice, and flows over a rocky bed covered with dark green confervae, abounding in beautiful trout, which, probably owing to the perpetual coolness of the stream, are always in season*: —

"VAUCLUSE.

"I see the rifted rocks above thy stream,
O Sorgue! and, as I trace its wave along,
A scene of pastoral beauty glads my eye,
Well suited to a pastoral poet's song; —
Meads that have gain'd their freshness from thy wave,
And fed upon thy dews, whiten'd with flocks;
And gentle slopes, where, 'midst the broken rocks,
The vines spread forth their branches to the sun
As if they gain'd their nurture from his beams;
And, in the richer soil, the olive turns
Its glittering foliage from the northern blast.
Along the hills the stately villa peers,
Embosom'd deep in cypress. On the plain
The cottages are spread, and many a row
Of trees in formal trim the pruner's art
Declare; fitted to bear the richest fruits
Pomona culls, or for the verdant food

* On the 10th of April, 1830, I found the temperature of the Sorgue at its source 54°.

Of that fair insect, daughter of the spring,
Whose industry supplies the Cimbrian looms.
I walk along thy banks ; — and now thy streams
Descend with more of power and sparkling foam.
Amidst their basins awful cliffs impend
Above thy channel, raised in many a form
Fantastical of spires and Gothic towers
And airy battlements ! As if in sport,
Nature in humouring her plastic strength
In playful mood had form'd them. In a dark
And gloomy chasm, crowded with broken rocks,
I see the white spray rise in many a cloud ; —
And now I hear the thundering cataract.
It is thy lofty spring, O wondrous stream !
Born of the mountain snows ! Thy course is made
In darkness and in silence, deeply hid
Within thy channel of the marble rock ;
And all at once thou risest into light,
Pure as if fresh from heaven ! Embosom'd long
In earth, thou hast no earthly taint. Thy hues
Seem stolen from the blue etherial sky,
So bright, so pure their lustre ; and thy foam
Is whiter than the snow that gave thee birth.
In thunder thou descendest from thy rocks !
Nor dost thou sleep beneath them ; murmuring still
Along thy pebbly bed, garnish'd with plants
Growing amidst thy waters, mingling hues
Of emerald with thy transparent blue.
I wonder not the poet loved thy wave,—
Thy cavern'd rocks, — thy giant precipice ;
For such a scene was suited well to break
The tyrant-spell of love and to controul.
A passion that was often hopeless love
Call'd for impressions strong and vigorous,
Such as this scene sublime might well bestow
Upon a mind alive to sympathy
With all created forms that bear the stamp
Of loveliness, or majesty, or grace."

The lines on Carrara, with which I shall conclude these poetical notices are without date ; but I believe they were written at this time, when he visited this remarkable spot on his way to Florence.

"CARRARA.

" Thine is no dark and dreary mine,
No hidden quarry damp and cold ;
Thy crests in orient sunbeams shine,
The morning tints thy rocks in gold —

"Thy rocks sublime, that still remain
As erst from chaos they arose,
Untouch'd by time, without its stain,
Pure as their canopy of snows!

"Forms worthy of that magic art
Which from the graver's potent hand
Can bid the hues of beauty start,
And all expression's power command;—

"Forms worthy of that master skill,
Which to the poet's dream has given
The noble front, the potent will,
Fix'd in the majesty of heaven;

"And that a softer charm has shed
On Cytherea's radiant head,
And kindled in her Grecian face
The immortality of grace!

"Scenes blended with the memory
Of mighty works can well supply
The food of thought,—and scenes like these
Have other natural powers to please.

"Around transparent rivers flow,
Whose tints are bright as summer sky;
Upon their banks the olives grow;
The greener pine, aspiring high,

"Towers 'midst the cliffs; the chestnut loves
Thy slopes, where vines their tendrils rear;
In the deep glen the myrtle groves
Embalm the cool and quiet air."

I shall now briefly revert to his scientific pursuits—the main object of his travels. From Paris he went directly into Auvergne, and examined the extinct volcanoes of that mountainous region. From thence he proceeded to Montpelier, where he resumed his inquiries on the combinations of iodine; the results of which he communicated to the Royal Society in a paper, which was published in the "Philosophical Transactions" of the same year. He crossed into Italy by the way of Nice and the Col de Tende; and passing through Turin, proceeded to Genoa, where

he remained a few days, and took the opportunity of making some experiments on the electricity of the torpedo, but without good results, probably partly owing to the languid state of the fish from the coldness of the season; and also of extending his inquiries on iodine. Both here and at Montpelier, in quest of this substance, he examined many of the marine productions of the shores of the Mediterranean, in most of which he found traces of it. But in the sponges, the ashes of which he tried, and bay-salt, he could not detect it.* Since, however, it has been detected by Dr. Fyfe in the former (Edinburgh Philosophical Journal, No. 2.); and, I may remark, that the results of my experiments on sponge are in accordance with Dr. Fyfe's; and thus confirming its important medicinal character and efficacy.

* If the sponges, the ashes of which my brother experimented upon, had been previous to incineration subjected to repeated washing, it may account for his not detecting iodine in them. I have found by this process that the greater part of the iodine is abstracted.

I may here add, that I have also detected slight traces of iodine in the coarse sea-salt of the Mediterranean, and which therefore I have been in the habit of recommending for use in families, and more especially in nurseries, in preference to refined salt. It is not improbable that the apparent increase of scrofulous and consumptive disease in recent times may be connected with the over refinement of salt, — that is, carried so far as to deprive it of its iodine principle, which seems intended by provident nature as a corrective of certain injurious causes productive of a terrible class of diseases. This view is confirmed by the remarkable difference in point of health in the population of certain mountainous districts of South America, as described by M. Boussingault in the 54th volume of the Annales de Chimie et de Physique, in some of which salt containing a very small proportion of iodine is used, and in others salt entirely destitute of iodine. As regards the public health and the happiness of families, the subject is of the first importance, and deserving of minute and thorough inquiry. Tubercular phthisis now carries off about one fourth of all who die in our own country,—the most interesting, and loved, and valued; hardly sparing a family. Its cure, when formed, is almost hopeless; its prevention is full of hope, and to this all our care should be given.

From Florence, where he arrived from Genoa in the middle of March, he wrote me the following letter, particularly referring to his scientific labours:—

"Florence, March 18. 1814.

"My dear John,

"I have written to you several letters, but I have not yet received one in return. This I attribute to the difficulty of communication, not to any want of kindness on your part.

"Write to me, alla posta, Roma. There is now full communication between Italy and England: and tell me all the news,—what you have done, what you have published, and what you are doing.

"I find the French chemists inclined to your views of animal heat, as a chemical process, and Le Gallois strongly opposed to Brodie; yet after much discussion, I have retained my opinion.

"We have made a most interesting voyage in eventful times. I have passed from the Pyrenees to the Alps, and have twice crossed the Appenines, and have visited all the most remarkable extinct volcanoes in the south of France. All the basalt that I have seen between the Alps and Pyrenees is decidedly of igneous origin. I have observed some facts on this subject that are, I believe, new,—a regular transition of lava into basalt, depending upon the different periods of refrigeration; and true prismatic basalt in the interior of an ancient lava.

"I have worked a good deal on iodine, and a little on the torpedo. Iodine had been in embryo for two years. I came to Paris; Clement requested me to examine it, and he believed that it was a compound, affording muriatic acid. I worked upon it for some

time, and determined that it was a new body, and that it afforded a peculiar acid by combining with hydrogen, and this I mentioned to Gay Lussac, Ampere, and other chemists. The first immediately "took the word of the Lord out of the mouth of his servant," and treated this subject as he had treated potassium and boron. The paper which I sent to the Royal Society on iodine I wrote with Clement's approbation, and a note published in the "Journal de Physique" will vindicate my priority. I have just got ready for the Royal Society a second paper on this fourth supporter of combustion.

"The old theory is nearly abandoned in France. Berthollet, with much candour, has decided in favour of chlorine. I know no chemist but Thenard who upholds it at Paris, and he upholds it feebly, and by this time, probably, has renounced it.

"I doubt if the organ of the torpedo is analogous to the pile of volta. I have not been able to gain any chemical effects by the shock sent through water; but I tried on small and not very active animals. I shall resume the inquiry at Naples, where I hope to be about the middle of May. In my journey I met with no difficulties of any kind, and received every attention from the scientific men of Paris, and the most liberal permission to go where I pleased from the government.

"I lived very much with Berthollet, Cuvier, Chaptal, Vauquelin, Humboldt, Morveau, Clement, Chevreul, and Gay Lussac. They were all kind and attentive to me; and, except for Gay Lussac's last turn of publishing without acknowledgment what he had first learnt from me, I should have had nothing to complain of; but who can controul self-love? It

ought not to interfere with truth and justice; but I will not moralise nor complain. Iodine is as useful an ally to me as I could have found at home. Tell me what you are doing, and what you wish; and command me as your affectionate friend, and love me as your very affectionate brother,

"H. Davy."

At Florence, where he remained rather more than a fortnight, he entered upon a new subject of inquiry, and which he prosecuted afterwards at Rome. This was the nature of the diamond, and of the different varieties of carbon. Many conjectures had been previously formed relative to the striking difference of qualities between the hardest and the most beautiful of the gems, and the more common forms of carbon as it appears in charcoal, anthracite, and plumbago. By one inquirer, the peculiarities of the diamond were supposed to be owing to the presence of a little hydrogen; by another, to the presence of a little oxygen; by a third, to perfect purity and crystallisation, and the presence of a little water of crystallisation; and, lastly, my brother conjectured that it might contain some new principle, some new supporter of combustion, to which it might owe its characteristic qualities. This idea he formed before he quitted England; and suggested it in a paper on the fluoric combinations, which was written before he was acquainted with the existence of iodine. He remarks: "As the investigation of nature proceeds it is not improbable that other and more subtle bodies belonging to this class (the supporters of combustion) will be discovered; and perhaps some of the characteristic differences of those substances, which

apparently give the same products by analysis, may depend upon this circumstance."

"The conjecture (he continues) appears worth hazarding, whether the carbonaceous matter in the diamond may not be united to an extremely light and subtle principle of this kind, which has hitherto escaped detection, but which may be expelled, or newly combined, during its combustion in oxygen."* And after the discovery of another supporter of combustion in iodine, even before his anticipation had been published, and of a new acid containing it, which, for a time, was supposed to be identical with the muriatic, he was strengthened in the probability of the idea, and determined, as soon as possible, to subject it to the test of experiment. At Florence he found the facilities required, and he immediately entered upon the inquiry. For making his experiments he was liberally allowed the use of the great lens in the cabinet of natural history, by means of which he was able to obtain simple and decisive results. The first fact he observed in using this instrument was, that when the diamond was once inflamed in oxygen gas, its combustion continued with great energy, like any other variety of carbon, unaided further by the solar heat. For the details of his processes, I must refer the chemical reader to the paper itself. The results were entirely negative. After the combustion of the diamond in oxygen gas there was no increase or diminution of the volume of the gas; no water was produced, — not the slightest trace; and the acid gas generated had the common properties of carbonic acid gas, — form-

* Phil. Trans. 1817, p. 42.

ing with lime carbonate of lime; and yielding charcoal, when decomposed by potassium. Moreover, when intensely heated in chlorine gas, by means of the lens, the diamond underwent no alteration. From these results the inference was unavoidable, that diamond is merely crystallised carbon; and from other results, obtained in experimenting, in a similar manner, on the common varieties of carbon, it was necessary to infer, that, though they all contain certain impurities, they are chemically essentially the same as the diamond, differing only in their state of aggregation, according to the original opinion of Mr. Tennant; and thus overthrowing an opinion which had almost become an axiom, and which my brother himself was disposed to adopt, "that bodies cannot be exactly the same in composition, or chemical nature, and yet totally different in all their physical properties."

In the beginning of April he quitted Florence for Rome; and, as I conjecture, took the Perugia road, which, to a traveller entering Italy for the first time, is much more attractive than the route by Radicofani. However, which of the two it was is of no importance; my only reason for believing that it was the former, is a description of scenery at this very season of the year, written from recollection some years after, with which he opens a chemical dialogue that was never completed. It thus commences: —

"SCENE — *The Appenines above Perugia.*

"*Poet.*—Notwithstanding the magnificence of the Alpine country, and the beauty of the upper part of Italy, yet the scenery now before us has peculiar

charms, dependent not merely upon the variety and grandeur of the objects which it displays, but likewise upon its historical relations. The hills are all celebrated in the early history of Italy, and many of them are crowned with Etruscan towers. The lake of Thrasimene spreads its broad and calm mirror beneath a range of hills covered with oak and chesnut; and the eminence where Hannibal marshalled that army which had nearly deprived Rome of empire, is now of a beautiful green from the rising corn. Here, the Tiber runs, a clear and bright blue mountain stream, meriting the epithet of cerulean bestowed upon it by Virgil; and there, the Chiusan marsh sends its tributary streams from the same level to the rivers of Etruria and Latium. In the extreme distance are the woods of the Sabine country, bright with the purple foliage of the Judas tree, extending along the sides of blue hills, which again are capped by snowy mountains. How rich and noble is the scene! How vast its extent! how diversified itscolours!"

The subject of the dialogue is the chemical elements. He chose this beautiful and impressive scene, belonging to history, to contrast the constancy of nature with the mutability of man, preliminary to explaining the laws on which that constancy depends.

He remained in Rome nearly a month, and then went to Naples, where he spent about three weeks. He returned to Rome in the last week of May, and left it in the first week in June, with the intention of passing the summer in Switzerland.

It is hardly necessary to observe, that both at Rome and at Naples he found unfailing sources of interest, as every person of an inquiring and reflect-

ing mind necessarily must, — where what is marvellous and beautiful in nature and art, of the past and of the present time, abound in such profusion, and occur in the most impressive forms. His last work, finished at Rome, his "Consolations in Travel," bear in almost every page indications of this interest, which even increased, I believe, in his after visits, and especially in his last, when, owing to his feeble state of health, ordinary sources of enjoyment were closed to him. The same work contains many allusions to the incidents of this time, and to the observations which he made during this or the following year. Thus, in the third dialogue, he mentions his "safe passage through a party of brigands who once stopped him in the passes of the Appenines." This occurred between Rome and Naples; and I have heard him say he had an amusing conversation in walking up a steep ascent of the road beyond Fondi with the captain of the party, who allowed him to pass unmolested, in compliment to his country. Thus, again, in the same dialogue, he describes the triumphant return from banishment and prison of the venerable Pontiff, Pius VII., and his entry into Rome, borne on the shoulders of the most distinguished artists, headed by Canova, which he himself witnessed.* And it was at Rome, not at Fontainebleau, I believe, that he had an opportunity of paying his respects to the Pope, "whose sanctity, firmness, meekness, and benevolence, he considered an honour to his church and human nature." It was during this period that he commenced those observations on volcanic action, and on the effects of deposition from water, which he

* May, 1814.

has described in the "Consolations," in connection with his peculiar views respecting the great changes which have taken place on the surface of our globe. And of the six dialogues, of which the whole of this work consists, the scenes of three of them are laid in Southern Italy; viz. in the Colosseum, on Vesuvius, and at Pæstum.

Amongst his note-books I can find but few remains which refer to this particular time. They are chiefly poetical, with a few notes on Somma. They may be worthy of insertion in further illustration of his tastes, feelings, and manner of observing.

The following lines to Canova, with whom he now became acquainted, and from whom he received great attention, could hardly have been written elsewhere than at Rome. Whilst they are a tribute to the excellence of the man and of the artist, they are no weak proof of my brother's admiration of the art; and may be brought forward in opposition to his hurried walk through the salons of the Louvre, described by Dr. Paris, as if he were insensible to the beauties of the arts of design, than which no opinion was ever more hastily formed or ill-founded.*

"CANOVA.

"Thou wast a light of brightness in an age
When Italy was in the night of art: —
She was thy country, but the world thy stage,
On which thou acted'st thy creative part.
Blameless thy life — thy manners playful, mild,
Master in art, but Nature's simplest child.

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* In opposition to the same statement, I may insert an extract from the diary which he kept the last time he was at Rome, referring in terms of high admiration to two statues then in the Vatican, and which had been in the Museum of the Louvre when he first visited Paris: — "Jan. 24th, 1829, went yesterday to the Museum, and admired the glorious works of old Greece, the Apollo and the Laocoon."

Phidias of Rome! like him thou stand'st sublime:
And after artists shall essay to climb
To that high temple where thou dwell'st alone,
Amidst the trophies thou from time hast won.
Generous to all, but most to rising merit;
By nobler praise awakening the spirit;
Yet all unconscious of the eternal fame,
The light of glory circling round thy name!"

The next lines are not less a tribute to nature, and a proof of the powerful influence which beautiful and impressive scenery was capable of exercising over his mind: —

"THE SYBIL'S TEMPLE.*

"Thy faith, O Roman! was a natural faith,
Well suited to an age in which the light
Ineffable gleam'd thro' obscuring clouds
Of objects sensible, — not yet reveal'd
In noontide brightness on the Syrian mount.
For thee, the Eternal Majesty of heaven
In all things lived and moved, — and to its power
And attributes poetic fancy gave
The forms of human beauty, strength, and grace.
The Naiad murmur'd in the silver stream,
The Dryad whisper'd in the nodding wood,
(Her voice the music of the Zephyr's breath);
On the blue wave the sportive Nereid moved,
Or blew her conch amidst the echoing rocks.
I wonder not, that, moved by such a faith,
Thou raised'st the Sybil's temple in this vale,
For such a scene was suited well to raise
The mind to high devotion, — to create
Those thoughts indefinite which seem above
Our sense and reason, and the hallowed dream
Prophetic. — In the sympathy sublime,
With natural forms and sounds, the mind forgets
Its present being, — images arise
Which seem not earthly, — 'midst the awful rocks
And caverns bursting with the living stream, —
In force descending from the precipice, —
Sparkling in sunshine, nurturing with dews
A thousand odorous plants and fragrant flowers.

* Tivoli.

In the sweet music of the vernal woods,
From winged minstrels, and the louder sounds
Of mountain storms, and thundering cataracts,
The voice of inspiration well might come!"

The following lines on Pæstum, like the preceding, are without date: whether they were written now or afterwards, is of little importance. The reader of the "Consolations in Travel" will discover in them that animated description of this celebrated spot with which he opens the third dialogue: —

"ON A DISTANT VIEW OF PÆSTUM.

"The mountains above were clear and bright,
Empurpled by the evening light.
Not a single cloud was seen in the sky,
But the wind was turbulent and high,
And full it blew on the Tyrrhene sea,
Which rose in billowy majesty:
Which rose, but not in its stormy hue,
For its colour was brightest, purest blue,
Save where it foam'd in crested pride,
White as the snow on the glacier's side.
Tho' loud the wind, and high the breeze,
Murmuring amidst the odorous trees,
Yet Philomel, as if to prove
More loud, as well as sweet, the voice of love,
Threw from the Caruba her thrilling song,
Her minstrel music wild and strong;
And gentle doves in thicket nigh,
Heaved, scarcely audible, their sigh.
Life seem'd in every thing to be! —
The blades of maize — the leafy tree —
The cones that shook on the giant pine
Seem'd moved by an impulse of power divine: —
Joy seem'd to dance in every thing;
The blast was from a zephyr's wing,
Moisten'd by that balmy dew
Which summer steals from spring,
Wafting each instant odours new.
Where faintly gleam'd the evening star,
Thy temples, Pæstum, from afar,
Upraised their marble columns bright
In the last gleams of purple light,

Above the wild deserted plain,
Where death and silence seem'd to reign,—
Temples, whose massy form and finish'd grace
Speak of the genius of a Grecian race."

The notes on Somma will be given a little further on, with some notices of the scientific researches in which he was engaged during the following winter and spring, on his second visit to the south of Italy.

Of his journey northward into Switzerland I have no particulars to communicate, and nothing of interest to relate, except that at Milan he had the pleasure of seeing Voltá, and the honour of forming the acquaintance of a philosopher to whom modern science lies under so great an obligation. My brother thus speaks of him in his Sketches of Distinguished Men, already alluded to: —

"Voltá I saw at Milan, in 1814, at that time advanced in years, — I think nearly seventy, and in bad health. His conversation was not brilliant; his views rather limited, but marking great ingenuity. His manners were perfectly simple. He had not the air of a courtier, or even of a man who had seen the world. Indeed, I can say generally of the Italian sçavans, that, though none of them had much dignity or grace of manner, yet they were all free from affectation."

From Milan he crossed the Alps by the Simplon, and arrived at Geneva in the last week of June. He remained there till the middle of September, residing in a country house, charmingly situated on the banks of the lake. These three months, I have heard him say, were spent very agreeably: the charm of the best society (chiefly English) was added to that of mag-

nificent scenery, and of a delightful summer climate; and he had besides the pleasure of angling. He was able even to enjoy his favourite amusement in the lake from the garden of the villa, which descended to the water's edge.

In returning to winter in Italy he visited some of the most remarkable scenery in the different cantons on the way to the Tyrol, through which he now passed for the first time. I shall extract from a note-book, two little descriptions of scenery, written at the moment, to record some of the peculiarities of a region of which he was ever after extremely fond: —

"October 6. 1814. — Detained at Inspruck two hours. Came to-day only two posts. The scenery to-day by far the finest I have seen in the Tyrol, and as fine as I have ever seen. Deep glens — in two of them two blue rivers, rolling and foaming over rocks of syenite and micaceous schist. The depth of the glens much greater than in Switzerland; narrow, and pine and birch below; then cultivated patches, and then pine, and birch, and larch again; and, above all, very high mountains, dark and frowning, but having snows on their gullies and bosoms, and on their tops. The sky harmonised with the grandeur and solemnity of the scene; it was clouded, but something like a soft October day in England. The clouds, of the purest white, played amongst the mountains, and gave to their dark firs and nodding rocks a deeper gloom by contrast. Now and then the sun burst forth, and made the yellow birch lighten into tints of gold."

"October 12. at Vicenza. — Left Trente yesterday morning at half past five o'clock, and passed

through some of the most beautiful scenery I ever saw. At first our road was up a mountain, where six horses were necessary. Features the same as those in the neighbourhood of Trente, and exquisitely beautiful; the valleys clothed with vines sporting round mulberry trees, elms, and fruit trees, and now displaying ripe grapes. The mountains all limestone, at least those so near as to enable me to judge of their nature; and blue, grey, reddish, or white. The town of Trente, in the midst of a highly cultivated valley, watered by the Adige; here a sober, pastoral, clear river, as large or larger than the Tay, containing trout, barbel, and eels, and probably a few grayling. The road from Trente to Bassano is exquisitely beautiful, and the beautiful passing into the sublime. When we came to the division of the waters (those which feed the Adige, and those that feed the Brenta), a rude sort of porphyry began to appear, and micaceous schist; and the hills crowned with snow, above the Brenta, probably were micaceous schist. On descending, variety of clothed hills, rich in the variegated vegetation of birch, oak, wild grape, thorn, clematis, &c.; a small lake, and then a larger one, beautifully wooded, sending a stream down, very small, to form the Brenta."

In returning to Rome he went by the way of Ferrara and Bologna, and crossed the Appenines to Florence. At Pietra Mala, in the midst of the mountains, and at the height of several thousand feet above the level of the sea, is a remarkable column of flame, of considerable magnitude, which is almost perpetually burning; and in the neighbourhood of it, in more than one place, the springs are agitated by the disengagement of air, which kindles on the

approach of a light, and burns with the same kind of flame as the great column. In passing through Pietra Mala, he had some of this air collected; and at Florence, on submitting it to analysis, he found it was carburetted hydrogen, similar to coal gas; and he, of course, inferred that it is of similar origin, probably produced from a bed of coal, acted on by subterraneous heat. These particulars he communicated to me, in a letter which I received from him during his journey, but which, with others written to me during this and his second journey on the Continent, have not, I regret, been preserved.

During the whole of this winter, which he spent at Rome, he was, as usual, variously engaged. The laboratory, the Campagna, and society, with the *et cetera* of this wonderful city, afforded him ample amusement and occupation.

The society was of that kind to which he alludes in his "Consolations in Travel,"—"numerous and diversified, containing many intellectual foreigners, and some distinguished Britons, who had a higher object in making this city their residence than mere idleness and vague curiosity."

In the *Campagna* and the adjoining country he took exercise with his gun, and completely recovered his youthful cacciatore taste; and from this time he continued to be almost as keen a fowler as he was before an angler. Nor is it more than might be expected that this taste should have revived here, where there is so much to excite it; the vast quantity of wild fowl, the great variety and succession of birds of passage, the peculiar nature of the ground, and the impressive features of the surrounding scenery.

The results of his chemical researches during this

winter he communicated to the Royal Society in three papers, which were published in the "Philosophical Transactions" for 1815, with the following titles and dates:—

"Some Experiments and Observations on the Colours used in Painting by the Ancients."—Jan. 14.

"Some Experiments on a Solid Compound of Iodine and Oxygen, and on its Chemical Agencies."—February 10th.

"On the Action of Acids on the Salts usually called the Hyper-oxymuriates, and on the Gases produced from them."—Feb. 15th.

The first of these papers is very well deserving of being studied by the enlightened painter, who takes an interest in the history and in the preservation of the works of his art: he will find in it an ample account of the colours which have proved permanent in ancient paintings; with suggestions for the selection of colours, and surfaces capable of resisting the effects of time, founded on chemical principles. Thus, in relation to surfaces, for perishable canvass, or copper, or wood, he recommends substituting plates of marble, or of a composition in imitation of marble; and, in relation to colours, he recommends excluding entirely all of animal or vegetable origin, all of which are more or less fugitive, and employing only such as are capable of resisting the severest tests of change, of which modern chemistry offers a sufficient number and variety: and, further, he recommends, at least for the great works of art, both in the mixture of the colours and the varnishing of the picture, the rejection of oil and resinous substances; substituting for oil-painting painting in fresco, and endeavouring to discover varnishes composed of unalterable materials.

The two other papers are purely chemical. One contains an account of a new compound of oxygen and iodine, which he succeeded in forming by passing euchlorine over iodine, when two combinations resulted; one consisting of chlorine and iodine, the other of oxygen and iodine; both solid, but which he was able to separate easily by heat, in consequence of their different degrees of volatility. He had previously, as has been noticed, discovered a class of salts in which iodine performed the same part as chlorine in the hyper-oxymuriates; and he now satisfied himself that this new compound in the iodine-salts acted as an acid, and neutralised the bases, and that when combined with water it exhibited the ordinary properties of an acid.

In his third paper he describes another new compound, which he obtained from chlorate of potash, by forming this salt (deprived of its water of crystallization by fusion) into a paste with strong sulphuric acid, and subjecting it to a very gentle heat in a retort of the smallest possible capacity. A deep greenish yellow gas was thus generated, of a brighter and more intense colour than euchlorine, and more readily and dangerously explosive. He found it composed of one volume of chlorine and two of oxygen, — the three volumes condensed by union into two. It immediately occurred to him, that euchlorine may be a mixture of this new gas and chlorine; and later experiments, especially those of M. Soubeiran*, and, I may add, some which I have made, appear to favour the idea that it is such a mixture, and not a definite compound.

Dr. Paris, in his life of my brother, in giving an

* Annales de Chimie et de Physique, tom. xlviii. p. 113.

account of his inquiries relative to chlorine, states, that after his discovery of the gas in question, he entered into "a very warm controversy with M. Gay Lussac respecting chloric acid (the discovery of this gentleman), and maintained an opinion regarding its constitution which he afterwards abandoned, and which Dr. Paris asserts he had reason to believe that he regretted ever having advanced.* Such a statement I consider in nowise warranted. As my brother's view of the composition of chloric acid was a mere statement of facts, it is most improbable that he should change it, much less regret it; and I am confident he did neither. The paper in which he expressed his ideas at most length on the subject, hardly deserves to be called warmly controversial; it is closely and powerfully argumentative, and an excellent example of discussion on a recondite chemical question. I shall give it below, that the chemical reader may judge for himself.† It is entitled, "On the Analogies between the Undecompounded Substances and

* Life, p. 210.

† "*On the Analogies between the Undecompounded Substances, and on the Constitution of Acids.*

"In a work published in 1812 (Elements of Chemical Philosophy), I have pointed out some of the analogies between the substances considered in the present state of our knowledge as undecompounded, and I have endeavoured to found a classification upon these analogies:—

"I placed oxygen and chlorine together, because, in combining with inflammable bodies and metals, they produce heat and light in a much higher degree than any other known species of matter, and because many of their compounds are possessed of analogous chemical and electrical qualities. At the same time I stated that there is a general chain of resemblance between all the chemical agents; and that while sulphur is analogous to chlorine in one of its properties, it possesses more general resemblances to phosphorus.

"The progress of chemical discovery since that time has added new links in the system of analogy, and modified some of the ancient links.

on the Constitution of Acids." It was published in the second number of the "Journal of Science and

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The singular body iodine, whilst it strongly resembles chlorine in most of its chemical qualities, is still more analogous than chlorine to sulphur; and in lustre, opacity, specific gravity, and the high proportional quantity in which it unites to other matter, it is similar to the metals. With the metals, indeed, it may be said to be distinctly connected by means of tellurium, which, as I have shown, by uniting to hydrogen, forms a substance having acid properties.

"Carbon, boron, and silicon, appear the links between phosphorus and sulphur and the metals; and probably the bases of zircona, glucina, and alumina, will form a part of the chain between the metals of the alkaline earths and the common metals.

"Hydrogen and azote stand almost alone; yet hydrogen is connected with the common inflammable bodies by the manner in which it combines with oxygen and chlorine, and azote resembles carbon in the proportional quantity in which it enters into combination, and in its want of attraction for metallic substances. Fluorine, probably, if it could be obtained insulated, would form the link between oxygen and chlorine and azote.

"M. Gay Lussac, in an elaborate paper published in the 'Annales de Chimie' for July 1814, in which he advanced many views, reasonings, and calculations, upon the composition of the compounds of chlorine, exactly the same as those I have given in three papers published three years before in 'The Transactions of the Royal Society,' endeavours to show that there is a stronger analogy between chlorine, iodine, and sulphur, than between the same bodies and oxygen; and he wishes them to be separated as a class from oxygen, and placed in a class with sulphur. I do not admit the force of his reasoning on this subject; the bodies to which he refers bear only one marked point of resemblance to sulphur, that which I have mentioned above; and they differ from it in their electrical relations, and in the chemical and electrical nature of all their other compounds, and agree in these respects with oxygen. Like oxygen, in voltaic arrangements they are determined to the positive surface, whereas sulphur is separated at the negative surface. The compounds they form with metals strongly resemble those formed by oxygen: they are electric, and many of them soluble in water, and possessed of acid properties; whereas those formed by sulphur are all non-electric and insoluble.

"I cannot admit M. Gay Lussac's views on the classification of the undecompounded substances, nor can I adopt his ideas respecting their properties as chemical agents. He considers hydrogen as an *alkalizing* principle, and azote as an *acidifying* principle. This is an attempt to introduce into chemistry a doctrine of occult qualities, and to refer to some mysterious and inexplicable energy what must depend upon a peculiar corpuscular arrangement. If hydrogen be an alkalizing principle, it is strange that it should form some of the strongest acids by

the Arts," edited at the Royal Institution; and was followed in the same number immediately by another

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uniting to bodies not in themselves acid; and if azote be an acidifying principle, it is equally strange that it should form nearly nine tenths of the weight of the volatile alkali. It is impossible to infer what will be the qualities of a compound from the qualities of its constituents; and if M. Gay Lussac's views were correct, the prussic basis of azote and carbon ought to have its acid properties diminished, and not increased, as he has proved them to be, by combination with hydrogen.

"When certain properties are found belonging to a compound, we have no right to attribute these properties to any of its elements to the exclusion of the rest, but they must be regarded as the result of combination.

"When M. Gay Lussac assumes that oxygen and hydrogen, in the proportions in which they form water, are passive as elements of a combination, it is a *pure assumption*, and opposed to the whole series of chemical facts. Hydrogen with chlorine forms a strong acid; oxygen with phosphorus forms a strong acid; and supposing water combined with the compound of phosphorus and chlorine, the results contain two of the most energetic known acids: phosphorane does not redden litmus paper; but if it be dissolved in water, it becomes a solution of muriatic and phosphorous acids.

"If oxygen and hydrogen, in the proportion in which they form water, are to be considered as passive, as neutralizing each other in all combinations in which they exist, then almost all the vegetable acids must be considered as acids of carbon, which, though containing much less oxygen than carbonic acid, and some of them less even than carbonic oxide, have yet strong acid powers.

"I have discovered a gaseous combination of four proportions of oxygen and one of chlorine, which has no acid properties. M. Gay Lussac has discovered a compound of two proportions of hydrogen, one of chlorine, and six of oxygen, which has acid properties; but he considers this substance merely as chlorine acidified by oxygen, and neglects the hydrogen, without which he allows, however, it cannot exist. He supposes that this acid of one proportion of chlorine and five of oxygen exists in all the hyper-oxymuriates, but he does not support his supposition by any proof. The hyper-oxymuriates are, as I showed six years ago, composed of one proportion of chlorine, one of a basis, and six of oxygen. Hydrogen, in M. Gay Lussac's chloric acid, may be considered as acting the part of a base; and it is an important circumstance in the law of definite proportions, that when one metallic or inflammable basis combines with certain proportions of a compound, all the others combine with the same proportions.

"M. Gay Lussac states, that if the chloric acid be not admitted as a pure combination of chlorine and oxygen, neither can the nitric or sulphuric acids be admitted as pure combinations of oxygen. This is

paper by him, "On the Prussic Basis and Acid," showing that he was most willing to do justice to M.

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perfectly obvious. An acid composed of five proportions of oxygen and one of nitrogen is altogether hypothetical; and it is a simple statement of facts to say that liquid nitric acid is a compound of two proportions of hydrogen, one of azote, and six of oxygen; and, as I showed long ago, the only difference between nitre and hyper-oxymuriate of potash is, that one contains a proportion of azote, and the other a proportion of chlorine.

"There are very few of the substances which have been always considered as neutral salts, that really contain the acids and the alkalies from which they are formed. The muriates and the fluates must be admitted to contain neither acids nor alkaline bases. Most of the prussiates, M. Gay Lussac has lately shown, are in the same case. Nitric and sulphuric acids cannot be procured from the nitrates and sulphates without the intervention of bodies containing hydrogen; and if nitrate of ammonia were to be judged of from the results of its decomposition, it must be regarded as a compound of water and nitrous oxide.

"Only those acids which are compounds of oxygen and inflammable bases appear to enter into combination with the fixed alkalies and alkaline earths without alteration, and it is impossible to define the nature of the arrangement of the elements in their neutral compounds. The phosphate and carbonate of lime have much less the character attributed to neutro-saline bodies than calcane (muriate of lime), and yet this last body is not known to contain either acid or alkaline matter. The chloriodic acid, the phosganic acid, and the binary acids containing hydrogen, combine with ammonia without decomposition, but they appear to be decomposed in acting upon the fixed alkalies or alkaline earths; and yet the solid substances they form have all the characters which were formerly regarded as peculiar to neutral salts consisting of acids and alkalies, though they none of them contain the acid, and only the two first of the series the alkalies, from which they are formed.

"The substitution of analogy for fact is the bane of chemical philosophy; the legitimate use of analogy is to connect facts together, and to guide to new experiments.

"As I cannot adopt M. Gay Lussac's opinions, so neither can I approve of his nomenclature. To call the compounds of chlorine and iodine chlorures and iodures, is to place chlorine and iodine in the class of inflammable bodies, and I prefer to these denominations chlorides and iodes. M. Gay Lussac has called sulphuretted hydrogen hydro-sulphuric acid; a term which has already been applied to sulphuric acid, the oil of vitriol of commerce. Hydro-chloric acid would signify chloric acid combined with water, and therefore, according to M. Gay Lussac's own views, is more applicable to his chloric acid than to muriatic acid."

Gay Lussac, and had pleasure in acknowledging his merit. It commences thus: — "In the last article I have defended some opinions of my own, and combated some of M. Gay Lussac's. In this article the object I propose is one much more agreeable to my feelings — to offer my experimental confirmation of the very elaborate and ingenious researches of M. Gay Lussac on the prussic acid and the prussic base."

It would be for the advantage of science were such a proceeding more frequently followed, and also his conduct in delicately abstaining from entering upon a subject of inquiry then prosecuted by another: thus, in this same paper, after having confirmed some of the principal results of M. Gay Lussac, he stopped, adding, he would "not detail any experiment of research on a subject which is peculiarly M. Gay Lussac's."

The following letter to my mother written at this time may be worth inserting, as showing the interest he took in the geological society then forming in his native town, and his feeling on the subject of the war then carrying on with America.

"Rome, Jan. 11. 1815.

"My dear Mother,

"Tell Betsy that I am much obliged to her for her kind letter, and delighted to hear that you are all well. * * * * *

"I am very happy to hear of a disposition to scientific activity in my native town, and shall be happy if I can do any thing to be useful to the museum. I will send to it some specimens from the Continent; and if there are subscriptions, pray get my name put down for 20*l.*

"We have almost as much society here as in London, and a great part of it our old friends. * * * * * * * *

"You get all the news much quicker than we do from Vienna. We all hope for a long peace. We all hope that the glory England has gained in a war for the defence of the liberty of Europe will not be thrown away; and that the petty squabble with America, which if successful can do nothing but increase our debt, will be speedily terminated.

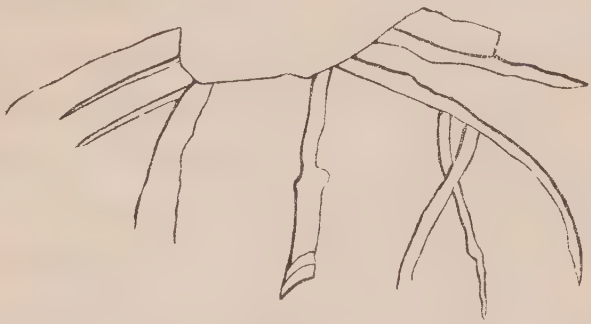
"A happy new year, and many of them, is the sincere wish of your affectionate son,

"H. Davy."

In the beginning of March my brother went from Rome to Naples, where he remained between a fortnight and three weeks. As in his preceding visit, his attention here was specially directed to the study of the surrounding volcanic regions, and the investigation of the phenomena of volcanic eruption. I shall reserve the statement of his results for a further occasion; in this place, I shall give merely the few rough notes which he wrote down at the time, chiefly respecting Somma, a mountain which excited greatly his curiosity, and which he many times explored, and carefully examined.

"Yesterday, March 16th, ascended Vesuvius, and went round the base of Somma, a most interesting mountain; strata of basaltic, leucitic, and hornblende lava, alternating with ashes, sand, and decomposed stones; some strata of lava vertical and like whin dykes; others more or less inclined; the whole a grand scene of confusion, as if a mountain formed of ashes and small eruptions beneath pressure

(probably of the sea) had been split in pieces, and its chasms filled up by very fluid stony matter injected from below." — He gives a sketch of the vein-like strata which characterise Somma, of which the following is a copy: —



" In Somma," he continues, " the lava has much the appearance of primitive rock, and one variety is much like the hornblende rock of North Wales.

" I think there can be no doubt that the eruption which raised the cone of Vesuvius split Somma asunder, and threw a part of it off towards the sea; — thus Vesuvius rises out of Somma."

He proceeds,—" *Quære*, Was this at the time of Pliny?

" Somma itself was evidently a very old mountain. None of the lavas of Vesuvius are to be compared to those of Somma for *crystallization*. As appears from Montecelli's collection, almost all the known minerals, primary and secondary, are thrown up by Vesuvius; and in the base of the mountain near the hermitage, one finds almost all the primitive rocks. Granite, the same as that of Cornwall, is found amongst the products of Vesuvius, and is probably a formation. Do not all these stones come from the grand deep reservoir where they are formed by slow crystallization? Nothing is more common in volcanic countries, than for a thin stratum of lava to rise through a mountain of ashes and to overflow them. This is the case at Monte Nuovo."

Deterred by the plague (which a short time before had broken out at Malta, and in the Levant), from extending his travels further to the eastward, as he had originally designed, he set out on his return to England; he again traversed the Tyrol, and avoided France by a detour through part of Germany and Flanders; embarked at Ostend; landed at Dover; and arrived in London on the 23d of April.

The only notes I have been able to find, kept on this homeward journey, are the few following, relating to his favourite Tyrol, and the north of Italy bordering on it:—

" March 30th, 1815.—I have again passed through the Tyrol as far as Botzin, where we arrived at half-past three this day. We quitted Verona yesterday morning, and came on to Trente, by the Roverido road. The mountains all limestone; and about a mile

from Roverido, a scene of savage wildness and desolation, such as I never before saw. The valley of stones in Devonshire is a miniature of it. The Adige does not contain much fish, and rolls through meadows with rows of mulberry trees. The olive is little seen after Roverido, but the vine is the tree of the country. The limestone mountains here begin to be topped with firs rising amidst the snows; the Mediterranean pine below, the Alpine pine above; Switzerland as it were mingling with Italy. The spring just beginning, but the weather very hot in the valley of Botzin; as hot as our July. The rocks just below Botzin very picturesque porphyry. The river very low and clear, but I think much larger than the Spey. Around Botzin very grand scenery; peaks of granite rising in the east and north from snowy mountains, pines below, and fresh wood in the valley, displaying the delicate green of early spring."

"April 2. — In going up the Bremen, observed two interesting phenomena. The rivers formed by the melting of the snow coming in contact with the warm air, blowing up from Italy, threw down steam from the air, so as to seem as if boiling. Saw a number of small glaciers, formed by the snow-water, trickling down amidst snow in the day, and frozen in the night. Pines and larches the abundant trees, after passing the Bremen. A number of fine castles on the mountains in the Tyrol."

It was either this spring, or the preceding autumn, when amongst the mountains of the Tyrol, that my brother received a present of a Tyrolese rifle from the hands of a patriotic native, who had used it in the war of defence, so long and so heroically, maintained against the invaders of his country. The manner of receiving this present was the following

as related in conversation by the distinguished and kind-hearted individual in whose possession it now is.* I shall give the narration, as I had it, from a friend who wrote it down an hour or two after hearing it, knowing how much it would interest me. After mentioning how he had formed my brother's acquaintance, when young in the voyage of life, and happy in the enjoyment of simple pleasures, Sir Walter Scott continued in his kind way: "There was one very good thing about him, he never forgot a friend; and I tell you a thing he did to me that makes me particularly say so. When he was travelling in the Tyrol, the old patriot leader, Speckbacker, was very ill, suffering from rheumatism, or something of that sort; and when he heard there was a great philosopher in the neighbourhood, he thought of course he must be a doctor, and sent to beg some advice about his complaint. Sir Humphry did not profess to know much of medicine, but he gave him something, which luckily relieved his pain; and then the gratitude of the old chief made him feel quite unhappy because he refused to take any fee. So Sir Humphry said, 'Well, that you may not feel unhappy about not making me any return for my advice, I'll ask if you have any old pistol, or rusty bit of a sword, that was used in your Tyrolese war of defence, for I have a friend that would be delighted to have any such article; and you may depend on its being hung up in his hall, and the story of it told for many a year to come.' Speckbacker struck his hands together, much pleased with the request, and said, 'Oh, I have the very thing! you shall have the gun that I used myself when I shot thirty Bavarians in

* This was written in the winter of 1831–2, just after Sir Walter Scott's visit to Malta.

one day.' The illustrious gun was given accordingly to Sir Humphry, who brought it with him on his next visit to Scotland, and deposited it with me, at Abbotsford, himself." *

The following letter to my mother was written soon after his return: —

"May 5. Nerot's Hotel, Clifford Street, London.

"My dear Mother,

"You will have heard from John of our safe return. I wrote to you from Naples, and from Brussels. I hope you received my letters.

"We have had a very agreeable and instructive journey, and Lady Davy agrees with me in thinking that England is the only country to *live* in, however interesting it may be to *see* other countries.

"I yesterday bought a good house in Grosvenor Street, and we shall sit down in this happy land.

"I beg you to give my best and kindest love to my sisters, and to remember me with all affection to my aunts.

"I am, my dear Mother,

"Your very affectionate Son,

"H. Davy."

* Sir Walter Scott, about the same time, in conversation with me respecting Dr. Paris's Life of my brother, strongly expressed his disapproval of it, as might be expected from his own kindly and generous nature. His manner was stronger than his words, of the dislike he felt towards it; he said, "I am not pleased with the book, it is not kindly or gentlemanly written." These, I believe, were his words; so I find them in a note of the conversation which I made immediately after, dated Dec. 7. 1831. I thought it desirable to put on record such a testimony of the highest authority, and right to give it, to counteract Dr. Paris's evil report.

END OF THE FIRST VOLUME.